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ABSTRACT

Abstracts of most of the papers presented at the 55th annual meeting of the National Association for Research in Science Teaching (NARST), held at the Abbey, Lake Geneva, WI, April 5-8, 1982 have been collected in this publication. Papers relate to such topics as teacher education: preservice and inservice, cognitive development, research techniques, metaanalysis, science learning and instruction, science education research in foreign countries, reasoning and problem solving, and science curriculum. (PEB)

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NATIONAL ASSOCIATION

FOR RESEARCH IN SCIENCE TEACHING

The Abbey

April 5 - 8, 1982

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
The Ohio State University
College of Education
1200 Chambers Road, Third Floor
Columbus, Ohio 43212

PREFACE

The ERIC Clearinghouse for Science, Mathematics and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 55th annual conference at The Abbey, Lake Geneva, Wisconsin, April 5-8, 1982.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Carl F. Berger and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Arthur L. White and Patricia E. Blosser
Editors

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December 1981

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Session A-1

EFFECT OF BACKGROUND EXPERIENCE AND AN ADVANCE ORGANIZER ON THE ATTAINMENT OF CERTAIN SCIENCE CONCEPTS

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This study examined two major questions: (1) the effect of an advance organizer on attainment of science concepts, and (2) the effect of background experience in science on the attainment of science concepts.

A population of 90 ninth graders, enrolled in an earth science class, was given the Dubins Earth Science Test, form A, a published earth science test, which had been modified by the researcher for this study. The same students were also given the Science Background Experience Inventory, an instrument developed by the researcher. On the basis of the experience score, the students were placed into high, medium and low experience groups. Each of the experience groups was further divided into a treatment and a control group.

The treatment group was given an advance organizer on the topic of the rock cycle and the control group was given a placebo on the same topic. A two week unit on the rock cycle was then taught to all students. At the end of the two weeks, the Dubins Earth Science Test, form B, was given to the students as a post-test. Additional data on sex, Differential Aptitude Test scores, socioeconomic status and grade point were collected. Analyses were performed on the basis of these results.

The conclusions of the study were: (1) the advance organizer made no significant difference in achievement as measured by the Dubins Earth Science Test; (2) the background experience of a student, as measured by the Science Background Experience Inventory, made no significant difference in achievement on the Dubins Earth Science Test. The background experience accounted for the variance on performance on the post-test to a small degree; (3) there was no significant interaction between the method and the background experience of the student; (4) there was a strong covariance relationship between the Differential Aptitude Test section on Abstract Reasoning and achievement on the Dubins Earth Science Test.

The results showing no significant difference due to treatment or background experience may have a number of interpretations. These include: (1) The possibility that the test instruments may not have been sensitive enough to register significant changes; (2) The population did not include the full spectrum of student abilities. This exclusion may have affected the outcome of the research; (3) The difficulties experienced in recording the time for completion may have masked an efficiency factor. That is, the amount of time necessary for completion of the unit may be significantly reduced by an advance organizer; (4) The teacher's presentation of the unit may have been so good that differences between the students are reduced; (5) The unit of study may not have been broad enough to allow for a maximum advance organizer effect; and (6) The retention of the treatment group may have been significantly greater but testing after a longer period of time would be necessary to measure this. These interpretations lead to many possibilities for future research.

Session A-1

THE RELATIONSHIP AMONG SELECTED DEMOGRAPHIC VARIABLES, STUDENT ATTITUDES AND SCIENCE ACHIEVEMENT

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Objectives

The purpose of this study was to explore the relationship between selected demographic variables, student attitudes and science achievement utilizing valid and reliable instruments with an appropriate representative sampling of subjects. To accomplish this purpose, data from the 1976-77 survey of seventeen year olds conducted by the National Assessment of Educational Progress was used.

NAEP data were not originally collected for causal research purposes, however, recent studies have demonstrated the feasibility and utility of this data source in ex post facto investigations (Suchner, Barrington, 1980), (Walberg, Haertel, Pascarella, Junker, and Boulanger, 1981).

Procedures

Because of the survey nature of the NAEP studies, individual cognitive and affective items were developed without the need for scales. The first step in this study was to logically and empirically develop cognitive scales within the NAEP data. The cognitive and affective items from NAEP Booklet 4 (N=3135) were analyzed using principle factoring with iterations and oblique-rotation. Factor analysis established ten scales from the affective items and a single achievement scale.

Results of item to scale correlation and examination of Cronbach alpha coefficients resulted in dropping two of the affective scales. Stepwise multiple regression procedures were then used to determine the amount of variance in science achievement that could be attributed to each of the eight attitude variables and selected demographic variables.

Results

The results ranged from 2% of NAEP science achievement variance being explained by student anxiety to 11.4% of the variance being explained by student motivation. Four factors accounted for a total of 16% of the variance in science achievement.

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Suchner, R. W. & T. Barrington. "Men's and Women's Attitudes and Information About Science, Health and Energy. A Secondary Analysis of the National Assessment of Eductional Progress." 1977 survey of young adults. Chicago: NAEP Evaluation Workshop paper, 1980.

Walberg, H. J., G. D. Haertel, E. Pascarella, L. K. Junker, & T. D. Boulanger. "Probing a Model of Educational Productivity in Science with National Assessment Samples of Early Adolescents." American Educational Research Journal, 1981, 18 (2), 233-249.

Session A-1

THE RELATIONSHIP AMONG COLLEGE SCIENCE STUDENT ACHIEVEMENT, ENGAGED TIME AND PERSONAL CHARACTERISTICS

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The relationships among college student science achievement, engaged time (observed and perceived) and personal characteristics of academic aptitude, reasoning ability, attitude toward science, and locus of control were investigated. Measures of personal characteristics were obtained from the subjects (N = 76) of a private, liberal arts junior college before observations began in the lecture classes for the quarter. Instruments used to measure personal characteristics were Scholastic Aptitude Test, Test of Logical Thinking, Test of Scientific Attitude, and Levenson's Multidimensional View of Locus of Control. Based on a random selection procedure, student engaged time was observed at least ten times for eleven lectures. Achievement tests were constructed and validated for the biology classes. Data were analyzed by multiple regression procedures. The average achievement scores were positively related to academic aptitude and reasoning ability ($p \leq .008$, $p \leq .04$, respectively). Positive relationships were found between observed engaged time and academic aptitude ($p \leq .02$) and a negative relationship was found between observed engaged time and reasoning ability ($p \leq .007$). Also a positive relationship was found between perceived engaged time and achievement ($p \leq .06$). Pearson product-moment correlations between achievement and observed engaged time were significant ($r = .23$, $p \leq .05$) as were the correlations between perceived engaged time and achievement ($r = .30$, $p \leq .009$). Measures of engaged time (observed and perceived) were also related to each other ($r = .47$, $p \leq .0001$). The study's data indicate that students who were observed to be engaged were low in reasoning ability or high in academic aptitude. Those who perceived themselves as being engaged achieved more. College instructors who have knowledge of student academic aptitude and reasoning ability may use this knowledge to improve achievement.

Engaged time measures were significantly related to achievement, which indicates an instructor should endeavor to keep the students as engaged as possible to enhance achievement. Students who are engaged or pay attention or perceive they are engaged or paying attending during lecture classes achieve more than students who are observed as non-engaged or perceive themselves as non-engaged.

Session A-1

SEXUAL DIFFERENCES IN ATTITUDES THAT ARE HYPOTHESIZED TO BE RELATED TO COGNITIVE PERFORMANCE IN SECONDARY SCIENCE WITH GRADE LEVEL AND TYPE OF SCIENCE COURSE CONSIDERATIONS

James Levin
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The purpose of this study was to collect and analyze baseline data on sexual differences in secondary school students' attitudes towards science. Attitudinal differences were also analyzed for the independent variables of science programs and grade levels. Data were collected from 988 students in grades ten through twelve, using a modified version of the Fennema-Sherman Mathematics Attitude Scales to represent attitudes toward science.

Reliabilities of the modified science subscales were all high ($>.83$). Multivariate analysis of variance (MANOVA) was used to analyze the data for the main and interaction effects of the independent variables of sex (male, female), grade level (tenth, eleventh, twelfth) and science program (advanced placement, academic, general, terminal). Significant differences ($p \leq .05$) were indicated for all main effects (sex, grade, science program). Interaction effects were not found. Mean separations for the various levels of sex, grade and science program were performed for all attitudinal subscales.

Females evidenced a significantly ($p \leq .01$) more positive attitude than males on three subscales; Attitude Towards Success in Science Scale, Science as a Male Domain Scale and Teacher Scale. Although not significant, males evidenced more positive attitudes on all of the remaining five subscales.

Eleventh graders evidenced significantly more positive attitudes than tenth graders on all but the Effectance Motivation Scale. Students in eleventh grade had more positive attitudes than twelfth grade students on all scales except Science Usefulness Scale, Confidence in Learning Science Scale, Science as a Male Domain Scale and Teacher Scale.

Positive attitudes decreased from advanced placement to terminal programs. Advanced placement students were significantly different from students in the other science programs. Academic students did not differ signficantly from general students except on the Father Scale; however, they were significantly different from the terminal students for all subscales. General students were also significantly different from terminal students except on the three subscales of Attitudes Towards Success in Science, Science as a Male Domain and Effective Motivation.

Session A-2

USING THE COMPUTER IN SCIENCE CLASSROOMS - A SYMPOSIUM

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Overall Summary:

The increased availability of microcomputers for instructional use has provided new opportunities for science educators. This symposium will examine several innovative applications of the computer in science classrooms. Data will be presented to evaluate these applications, and the participants will suggest strategies for generalizing the results to additional settings in science education.

The presentations in this symposium will cover strategies for teaching specific concepts in science and for helping students to develop more generalized problem-solving skills. This symposium will also focus on such factors as dynamic reading from computer screens, group size, and variations in the sequence or type of guidance provided to learners. Methods for conducting formative and summative evaluation by computer will also be discussed. The final presentation will integrate research on several different aspects of computer usage. The chairman and discussant will promote discussion to integrate the studies and to stimulate generalization to new areas of research and application in science education.

The individual abstracts give a more precise description of the topics covered in this symposium.

OPTIMAL GROUP SIZE FOR IMPROVING PROBLEM-SOLVING SKILLS WITH MICROCOMPUTERS

Dorothy Cox
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Three interactive problem-solving microcomputer programs using topics from life science, social studies, and environmental education were constructed by the researcher and administered to seventh and eighth graders in a suburban metropolitan school system. Group size at the computer varied from one to five subjects at a time. Optimal size of working group was found to be more than one and less than five. Suggestions for applying the results to other computerized educational settings will be discussed.

CLASSROOM STUDIES USING FEATURE IDENTIFICATION TASKS

Arthur L. White
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An attribute-identification concept-learning task was designed for administration by use of the Apple II microcomputer. A simulation of a chemical system presented the results of a chemical reaction to students. The program included graphics which were animated to present chemical and physical changes which are often observed in qualitative chemical analysis.

The students observed the results of each experiment and were asked to indicate the changes observed. The students were then asked to determine what changes in the system were indicators of the presence of a given substance. This study summarizes data from different sequences of experiments in order to explore effectiveness of sequence in concept acquisition.

COMPUTER IN BIO EDUCATION: AN OVERVIEW & INTEGRATION

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While some life scientists have used computers in biological education for over 15 years, it is only within the last five years that a considerable number are becoming involved. Current usage is characterized by the diversity of when, where, how and why computers are employed to enhance bio education. Computers are used from introductory biology through graduate courses, and from cell biology to ecology. They are used in courses for majors and for non-majors, and in both lectures and laboratories. They are involved in information retrieval, automatic data accumulation, and simulation--to mention only three uses. Computers allow biologists to teach what they already teach, but better; and to teach what is impossible to teach without them. As more bio educators use computers in their courses, they are demanding more sophisticated computer systems. Limited funds demand integrated planning of educational computer use at the department level to assure the greatest educational benefit for the most students.

USING COMPUTER GENERATED TASKS IN THE SCIENCE CLASSROOMS

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Science teachers have responsibility for both formative and summative testing. The burden can be considerable--preparing tests, administering them, scoring answers, and insuring test security all take time. Microcomputers can be used to carry out many of the routine testing chores in a science classroom using items from test pools the teacher prepares. The computer can be programmed to present test items, accept and score responses, record results, and report to both students and teachers on individual and group progress. Examples of computer programs to carry out these testing functions will be described and demonstrated.

COMPUTER SIMULATIONS TO TEACH PROBLEM SOLVING SKILLS IN BIOLOGY

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There are many experiments in biology which cannot be performed in biology classrooms because the experiments would be time-consuming, expensive, dangerous, or inconvenient for some other reason. Electronic computers make it possible to perform many of these experiments as computerized simulations. Examples of the use of BALANCE (which simulates the predator/prey relationship in nature) and PLANT (which simulates plant growth under varied light conditions) will be presented. Data will be provided to demonstrate the effectiveness of these programs under varying degrees of guidance as tools to teach scientific problem solving skills.

RESEARCH IN COMPUTER BASED LEARNING

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A variety of modes of computer use in science classes are reviewed, based on examples developed at the Educational Technology Center at Irvine. Two research projects concerning Computer Based Learning will then be discussed. One concerns dynamic reading from computer screens, and one concerns use of material by groups of students.

Session A-3

THE ELEMENTARY LEVEL SCIENCE METHODS COURSE: BREEDING GROUND OF AN APPREHENSION TOWARD SCIENCE? AN ETHNOGRAPHIC STUDY

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Elementary education majors generally teach all school subjects. Therefore, they receive their preparation in math, reading, language arts, social studies, and science. Teacher educators have long recognized and reported on the elementary teachers' apprehension toward science and the teaching of science.

In a field study consisting of fourteen weeks of weekly observations in elementary education majors' science methods classes, interviews with elementary education majors, and interviews with course instructors, it was revealed that science is being perceived by the elementary education majors as a body of knowledge that must be mastered before one may feel comfortable teaching any science at all. The dependence on content, or the factual aspects of science, by elementary education majors in the science methods classes was very apparent. Emphasis on content acquisition is stressed, by the students, to such a degree that the elementary education majors' comprehension about the processes and nature of science may be lost. There appeared to be a potential for confusion, by the elementary education majors, about what science represents.

The introductory science classes the elementary education majors enroll in stress the empirical aspects of their respective disciplines, i.e. learning the vocabulary of the discipline, its definitions and theoretical tenets, and manipulating the tools unique to that scientific discipline. The total number of science courses an elementary education major must take is two, but these two courses appear to have an impact on the students' perception of what is important when studying science. On the other hand, the science methods classes stress the processes of science, the elementary science curriculum programs (which are process oriented), and the teaching methodologies used in elementary science. The students in the study appeared, however, to use the process oriented methods courses to learn scientific content material in an attempt to alleviate their self-recognized deficiency. These two different approaches to the study of science, one content oriented, the other process oriented, may contribute to elementary education majors' confusion, insecurity, and avoidance of science. The confusion may be seen as an 'antagonistic dilemma,' pitting science as process, the approach of the methods course, against science as content, the perceived view of the students which is exacerbated by the students lack of depth in science content. Such 'antagonistic dilemma' may be manifest in the lack of instructional time accorded to science by elementary school teachers.

New strategies for the training of elementary education majors in science need to be examined. Strategies are needed which avoid the 'antagonistic dilemma.' Manipulation of course sequence, placing methods courses before content courses, is one potential alternative to relieve the apprehension felt by elementary education majors toward science. Another possibility is to have elementary education majors receive their science content instruction from science education faculty, individuals who are cognizant of and sympathetic to the plight of the elementary education majors. Such courses could then stress the same type of objectives the elementary science programs would stress. Alternatives to the present system of educating elementary teachers in science are needed since the present system appears to develop an apprehension and insecurity toward the teaching of science.

Session A-3

THE EFFECTS OF SYSTEMATIC FEEDBACK ON THE TEACHING PERFORMANCE OF UNDERGRADUATE INTERNS

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Observation of student teachers and follow-up conferences have been conducted as an integral component of teacher education. However the nature of the observation, evaluation and feedback has been left to the discretion of the observer in many cases. Thus, the idiosyncrasies of the supervisor often dictate the form and the substance of these activities. The development of instruments to assess generic teaching skills such as those used for certification in Georgia and South Carolina has provided tools which may be useful in the clinical supervision of both inservice and preservice teachers.

Purpose

The purpose of this study was to assess the effects of systematic feedback on the subsequent teaching performance of early childhood student teachers.

Procedures

Twenty-six student teachers in grades K-5 were randomly assigned to either a treatment or a contrast group. Students in the treatment group taught a lesson which was observed by an instructor in elementary methods. After the lesson the instructor rated the student on the Teacher Performance Assessment Instruments (Capie, Johnson, Anderson, Ellett, and Okey, 1979). The student discussed each of the TPAI ratings with the instructor who explained each of the ratings, citing specific examples in the lesson. This discussion required 30 to 60 minutes. During subsequent observations and conferences no mention was made of the TPAI ratings. The contrast group also taught a lesson early in the field experience and discussed it with the same instructor. This discussion was focused on particular elements of the lessons, with suggestions for improvement. This session was similar to conferences used in this context for a number of quarters. During a later conference students in the contrast group discussed TPAI ratings with this instructor.

After the initial lesson and before any other observation and conference, all students were observed by an instructor in science methods who completed a TPAI assessment of each of the students. He was uninformed of the nature of the experiment or of the treatment group of the students. Students were not aware that he was gathering TPAI data. Thirty items rated on a five point scale were used. Rho-squared values greater than .8 have been reported for both instruments used in this study (Capie, Tobin, Ellett and Johnson, 1980).

The TPAI ratings of the science instructor were used in the analyses. Univariate analyses of variance were completed on each of the items. A descriptive discriminant analysis using stepwise procedures and Wilk's criterion was used to provide a more parsimonious description of the differences in the performance of the groups.

Results

Seven of the rating items showed significant differences ($p. \leq .05$) favoring the treatment group. Four additional items approached significance ($p. \leq .10$). Only one mean favored the contrast group.

The discriminant analysis revealed one discriminant function which was highly correlated with treatment group (canonical correlation = .998). When discriminant coefficients were used to produce scores, all subjects were correctly placed in treatment groups.

Discussion

Certain students were told how to better their scores on the TPAI. And, they did. However, the data collection procedures suggest that the students had little reason to suspect that the TPAI were being used or that the instructor who introduced them was aware of the performance in the later lesson. The particular indicators where substantial differences were identified support the notion that students spontaneously used the behaviors in the TPAI. Tentatively, at least, rather specific managerial behaviors are more easily enhanced by systematic feedback than are general traits such as enthusiasm.

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Session A-3

STUDENTS' RATING OF INSTRUCTION IN ELEMENTARY SCIENCE METHODS COURSES

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This study analyzed the relationships of students' beliefs about traditional/inquiry science teaching and their rating of course/instruction in elementary science methods courses. During the semester elementary pre-service teachers were introduced to various methods of teaching science in the elementary school. These included discovery teaching, guided discovery teaching, rational inquiry teaching, teaching with learning centers, teaching with science units, and textbook oriented science teaching. One of the overall objectives of the course was for students to develop or adopt various teaching styles which they felt they could implement most effectively.

Subjects for the study were 169 college students enrolled in six elementary science methods courses. The six sections were taught by two different instructors. During the last regular class meeting the students completed a science teacher ideological preference scale and a course/instruction evaluation questionnaire. The instructors also completed the science teacher ideological preference scale. A Pearson r statistic for each student was computed to determine the amount of correlation between student's beliefs and instructor's beliefs on the science teacher ideological preference scale. These correlation coefficients were then utilized to divide the students into three groups: those where instructor-student beliefs were highly similar, those with similar beliefs, and those with dissimilar beliefs. A one-way analysis of variance was then used to check for significant differences among the groups in their instructor/ course ratings for the five subscales and for the total instruction/course rating scores.

A total of eighteen one-way analyses of variance were carried out. These involved the five subscale scores and the overall rating score for the total group and for both separate instructor groups. Four of the eighteen analyses showed significant differences beyond the 0.05 level. These related to the subscales of general course attitude, and method of instruction as well as the overall rating. No differences were found for the subscales course content, interest and attention, and instructor.

This study revealed that students' beliefs about teaching science in the elementary school may influence their ratings of course/instruction at the higher education level in some instances. However, it also revealed that student ratings of courses and instruction at the higher education level is a very complex matter. This is aptly pointed out by the fact that the same significant differences were not found for the total group and for each instructor group in this study. Additional research studies are needed to further clarify these findings and also to study whether other student or course characteristics interact with their ratings.

Session A-4

THE RELATIONSHIPS AMONG LOGICAL AND SPATIAL SKILLS AND UNDERSTANDING GENETICS CONCEPTS AND PROBLEMS

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The purpose of this study was to determine whether relationships occur among spatial skills, logical reasoning and various genetics concepts. The design included twenty-one students enrolled in basic undergraduate genetics courses in northern New Jersey institutions. These students completed a series of tests and tasks designed to measure flexibility of closure, visualizaton, proportional schemata, induction, propositional logic, and understanding of genetics concepts.

Preliminary correlations and factor analyses showed that certain topics in genetics are strongly associated with visualization skills, proportional schemata, induction and disjunctive reasoning. It may be inferred that the cluster of genetics items concerning the number of gamete genotypes, mitosis, meiosis (from gametes to diploid cell), calculating gene frequency, the trihybrid test cross, the pedigree and the relationship between a DNA sequence and its complimentary RNA sequence have something in common with each other that is not measured by the tests and tasks for visualization, logical reasoning, flexibility of closure and scheme of proportionality used in this study. Interestingly, the Hidden Patterns Test and items concerning map units have something in common and load heavily in a factor. The data from this study were interpreted with caution, as the sample size was small and the variables were both continuous and dichotomous in nature.

Further research concerning these relations and possibly others is recommended in light of the increased use of microcomputers as instructional devices in biology classrooms. This information may provide criteria that could be useful to teachers selecting or writing programs for their genetics courses or for biology teachers preparing genetics units.

Session A-4

THE IMPORTANCE OF VISUO-SPATIAL APTITUDE IN THE UNDERSTANDING OF BIOLOGY CONCEPTS

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The biological sciences have long been ignored in studies of spatial thinking as related to various occupations. Only in the last decade has evidence begun to accumulate that indicates a visuo-spatial cognitive linkage to biology. In order to further examine this possible relationship, a study was conducted on eighty undergraduates majoring in the sciences. Forty liberal arts majors were also tested in the study to note any similarity or difference in the two populations.

One hundred and twenty subjects were administered a series of visuo-spatial tests from Ekstrom et al Kit of Factor Referenced Cognitive Tests (1976). The series included tests for spatial orientation, spatial visualization and flexibility of closure. Utilizing the results, the biology population was divided into a control and an experimental group consisting of twenty males and twenty females. Group selection was random, but pretests scores were checked to assure that high and low spatial students were included in each group.

Throughout the year, subjects in the experimental group were given laboratory exercises aimed at developing their spatial perceptive capabilities. These exercises were based on suggestions by Bishop (1973), Adamson et al (1979) and Reid (1980) and developed by the researcher for the biological sciences. The biology control group received exercises from a marketed general manual that involved little visuo-spatial understanding. The non-science group received no laboratory practice. At the year's end the entire population was given other visuo-spatial tests from the Ekstrom battery.

Siemankowski and MacKnight (1977) had found that students majoring in science disciplines were significantly higher in spatial aptitude than students in non-science curricula. It was not surprising therefore to note that a student who had selected biology as his field of specialization scored much higher on the spatial tests than the non-science major. Interestingly, the females in the population who had selected biology as their major also scored significantly higher on the tests than the females who selected non-science disciplines. Equally as important was the finding that the female biology majors scored as well or better on the tests as the male non-science popluation. This result seems contradictory to the notion that males are more spatially gifted than females (Smith, 1964; Harris, 1978; McGee, 1978). However, when one realizes that roughly twenty-five percent of all women tested for visuo-spatial accuracy score higher than the median for men on the test, the results should not be so surprising (Maccoby and Jacklin, 1974). In addition Eisenbery and McGinty (1977) noted that women found in occupations traditionally seen as men's (i.e. physics) scored significantly higher on spatial tests than their male counterparts. Kelly (1976) noted that a large proportion of women in communist countries score very high on tests for spatial perceptive ability.

These findings are surprising, however, because they contradict earlier studies performed by Holzinger and Swineford (1946) and I. M. Smith (1964) that found no correlation between the two areas.

The research indicates also that a student's spatial ability can be significantly increased through interaction. Students in the experimental populations scoring low on the pretest showed significant improvements in their spatial posttest scores. This was not the case with the low spatial visualizers who received no interactive exercises. This study therefore supports the finding of Brinkmann (1966), DeBono (1976) and Rosenthal et al (1977) that suggest that spatial thinking can be strengthened and improved through practice.

Yet encouragement of spatial perception in the nation's schools is sadly being neglected. Today's education is still a highly verbal experience. This

has penalized the large number of students who conceptualize in a spatial framework. In addition, education that stresses only verbal attributes in the individual deprives him of his spatial potentials.

This study has revealed that spatial perception is a contributing factor to the success of biology conceptualization. In addition, spatial perception can be greatly enhanced in the low spatial thinker through interactive exercises.

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Session A-4

FURTHER ANALYSIS OF GENDER RELATED DIFFERENCES IN SPATIAL FUNCTION

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In previous investigations on gender related differences associated with performance in science it was found that: 1) Significant gender related differences existed in correlation between Visual Disembedding Ability and Achievement in Science (and that that difference was the most significant among considered factors, including Locus of Control); and 2) Significant gender related differences existed in cognitive correlates of performance on the test of Visual Disembedding Ability (GEFT). This investigation focused on further analysis of gender related differences in spatial function (the cognitive domain in which significant gender related differences have been identified), and on a preliminary analysis of personality and experience correlates of groups defined by gender and achievement in science. The outcome of this study is a clarification of factors associated with those groups, with particular attention given to group specific interactions between spatial function, personality and experience factors. A hypothesis of this study was that present debate on causes of gender related differences in science achievement is premature, since the nature of differences associated with gender and achievement are not clear.

Session A-5

THE CONCERNS BASED ADOPTION MODEL FOR MANAGING AND EVALUATING IMPLEMENTATION

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Examination of the science education literature regarding implementation of new programs suggests three areas where researchers need to improve their skills. They are:

1. Strategies for assessing the nature and extent of implementation;
2. A data-based decision making process for assisting in the facilitation of change; and
3. A model that provides a theoretical base from which to understand the change process.

The results of the research by Weiss (1978) and others indicate that the number of classrooms reporting "use" of one of the NSF curricula is low (7% or less). However, even in this bench-mark study, the word "use" is not defined. Criteria for establishing "use" would be needed before these data could be appropriately interpreted. Numerous studies have been reported which compare the relative effectiveness of programs, but only rarely does the author report having established whether or not the program was actually in place at the time the evaluation was conducted. Most schools appear to concentrate all their efforts on pre-implementation activities, while ignoring the suggestions in the change literature that long term support is necessary for effective implementation.

The Concerns Based Adoption Model (CBAM) provides a theoretical base for understanding the change process. The dimensions of the CBAM: Stages of Concerns (SoC), Levels of Use (LoU), and Innovation Configuration (IC), provide strategies for assessing the nature and extent of implementation. These strategies in the context of the overall Model enable change facilitators to suggest data-based decisions about the next logical step in the implementation process.

This training session will provide an overview of the CBAM Model with its three dimensions and will develop skill in the collection and interpretation of concerns data. Further information sources will be provided and additional opportunity for training will be available to interested participants.

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Session B-1

THE RELATIONSHIP OF COGNITIVE STYLE TO THE DEVELOPMENT OF POSITIVE ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING IN ELEMENTARY SCHOOL TEACHERS

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Research into factors that are related to the development of positive attitudes toward science and science teaching has generally failed to identify any demographic or academic variables of consequence. Recent research (Bowles and Boss, 1974; Krajkovich, 1978) has indicated that cognitive variables, specifically the cognitive style of field dependence-independence may help to explain the differences in attitude development. A second cognitive style, tolerance for ambiguity, by definition (Budner, 1962) seems likely to account for some of the variance in teachers' attitudes developed during participation in an inquiry-oriented methods course.

This study was designed to determine the relationship of a subject's field dependence-independence and tolerance for ambiguity cognitive styles to the development of positive attitudes toward science and science teaching through participation in a science methods course that stresses the philosophies, designs, and activities of the SAPA, SCIS, and ESS curricula.

The subjects were 33 undergraduate humanities and social science majors who were minoring in elementary education at Rutgers University. The subjects were a reasonably homogeneous group of students who had little or no background in science.

The design involved a pre and posttest of attitudes toward science and science teaching with a measure developed by Moore (1973). Cognitive style was assessed by use of the Group Embedded Figures Test (GEFT) developed by Witkin, et al. (1971) and the Tolerance-Intolerance for Ambiguity scale developed by Budner (1962). A locally developed test of logical reasoning, known to be correlated to cognitive level, was also administered.

Multiple regression analysis of the data permitted the computation of partial correlations between the cognitive style variables and the residual variance in the attitude variables after the variance attributable to logical ability (cognitive style) and pretest performance were regressed out.

Results indicated that neither cognitive style was significantly related to the attitudes the subject held before the course, but that field dependence-independence was significantly ($p \leq .05$) related to attitudes toward science after the course and accounted for 15% of the residual variance. Tolerance for abiguity was significantly related to both attitudes toward science and attitudes toward teaching science ($p \leq .01$ in both cases), and accounted, respectively, for 22% and 27% of the residual variances in the two attitude scores. Furthermore, by varying the order in which the cognitive style variables entered the regression equation, it was found that tolerance for ambiguity was able to explain significant amounts of the residual variance in attitudes after the correlation of the two cognitive styles was taken into account; field dependence was not able to do so.

The results to this study indicate that the cognitive style of a teacher may contibute significantly to the development of attitudes toward science and science teaching in an inquiry-oriented methods course and that a high tolerance for ambiguity may be particularly important in the development of positive attitudes. This may help to explain why many teachers failed to adopt the NSF curricula after being trained to use the curricula in science methods courses and workshops.

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Session B-1

COGNITIVE AND PERSONALITY FACTORS ASSOCIATED WITH SUCCESS IN SCIENCE FOR BIOLOGICAL AND PHYSICAL SCIENCE MAJORS

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One hundred and eighty males and females were tested to determine what combination of factors related to success in science were present in the biological, physical science and non-science majors. The factors examined were mathematical and spatial ability, personality type, psychological masculinity and femininity, and attitude toward science.

The subjects were given a spatial rotation test, Cube Comparisons, developed by Educational Testing Service; a test of psychological masculinity and femininity, the Personal Attributes Questionnaire, developed by Spence and Helmreich; and the Myers-Briggs Type Indicator, a Jungian Personality measure developed by Isabel Myers. The subjects' SAT quantatative score was used as a measure of mathematical ability and a short questionnaire rating science as a desirable career measured attitude.

The data indicate that the personality of males was different from the personality of females primarily in terms of decision making. Males preferred to make decisions based on logical analysis and females preferred to make decisions based on personal values. Males also had higher SAT mathematics scores than females. Science majors had higher SAT mathematics scores than non-science majors, but this is attributable to the higher mathematics scores of the physical science majors. There was no difference in SAT mathematics scores of biological and non-science majors.

All the science majors had the expected scientific personality on the Myers-Briggs Type Indicator. They were thinking, intuitive and judging. The non-science majors exhibited the opposite characteristics. They were sensing, feeling and perceiving. Male science and non-science majors and female physical science majors were psychologically masculine. The female non-science majors were all psychologically feminine and the female biology majors were equally distributed between the categories of masculinity and femininity.

Science majors had a positive attitude toward science and were planning a scientific career. Non-science majors had a negative attitude toward science and were not planning a science related career. There was no difference between sexes or among groups for spatial ability.

It appears that mathematics as a factor in success in science is more important for the physical sciences than the biological sciences. The scientific personality and psychological masculinity and femininity were also factors more strongly related to physical science than to biological science, especially for women. These factors may be related to the fact that there is a larger number of female Ph.Ds in biology, 25%, than in physics, 4.3%, reported for 1975-76 by the National Science Foundation.

It also points out that any form of compensatory education to increase the number of women in science must also include a program of early identification of those young girls who exhibit characteristics of the scientific personality. Such programs should also make clear that so-called psychologically masculine traits such as independence or self-confidence are cultural stereotypes and as such do not make a woman less female. Nor does the possession of such traits prevent a woman or man from having the warmth and nurturance attributed to psychological femininity.

Session B-1

SEX, FIELD DEPENDENCE AND SCIENCE ACHIEVEMENT: A TRAIT-TREATMENT INTERACTION

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The cognitive style of Field Dependence-Independence (FDI) is related to a number of educational variables, including attitude and achievement in science, as well as to choice of academic major and career (Witkin et al, 1977). It also interacts with other student traits, and with teaching strategy, in the case of achievement (Douglass and Kahle, 1978) and attitude (Witkin et al, 1977). In particular, males and females are known to differ both in FDI and attitude toward science. They also differ in success in science and entry into science as a profession.

This study is an evaluation of the relative influence of FDI on the attitudes and achievement of students in very open, self-paced and highly individualized ISCS classrooms. It was anticipated that there would be interactions between the traits of FDI and sex in such a setting.

Subjects were 119 students in grades 7 through 9 in a large urban New Jersey school district. They were administered the Sequential Test of Educational Progress - Science at the beginning and end of the school year. They were also administered the Image of Science and Scientists scale and the Group Embedded Figures Test (GEFT).

There was an increase in achievement (STEP) and a decrease in attitude (Image of Scientists) from the seventh to the ninth grade. Attitude scores were uncorrelated with GEFT scores. Achievement scores rose sharply at all grade levels from pretest to posttest.

As anticipated, there was virtually no change in achievement from seventh to ninth grade for Field Dependent students. Field Independent students, on the other hand, showed continuous growth in achievement. Similarly, males showed little growth across these grades, while females had substantially improved STEP scores. The highest mean on the STEP posttest was achieved by Field Independent females, and the lowest by Field Dependent males.

We conclude from this study that attitude is unrelated to the cognitive style of Field Dependence-Independence. The curriculum appears to be effective for females and for Field Independent subjects, but not for males or Field Dependent subjects.

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Session B-1

EVALUATING REASONING ABILITIES OF FRESHMEN BIOLOGY STUDENTS FOR THEIR UNDERSTANDING OF LOGICAL CONNECTIVES

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The purpose of the study was to evaluate the reasoning abilities of college freshmen biology students in their understanding of the logical connectives, or disjunction (inclusive and exclusive), conditional (if-then) and biconditional (if and only if).

Eighty four (84) subjects enrolled in a first year experimental biology class, funded in part by an NSF grant, at a major eastern university were administered the pieces task. This test developed by Pallrand et al has a syllogistic format with a major premise, a minor premise and a conclusion.

Results of the test indicated that students in this course had difficulty with the logical connective or, both exclusive 40.4% correct and inclusive 54.2% correct. This is in agreement with studies conducted by Niemark (1970), Sternberg (1979) and Staudenmayer & Bourne (1977) which showed students have problems with the disjunctive "or".

An ANOVA yielded a 45.7 F-value for a question variable. Students seem to have problems going from one type of question to another.

Research is needed to determine whether topics and methodology used in this experimental biology course aided students in comprehending the conditional connective (if - then) which is necessary in understanding the hypotheses.

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Session B-1

A THREE YEAR STUDY OF TWO DIFFERENT APPROACHES TO TEACHING COLLEGE INTRODUCTORY GENERAL BIOLOGY

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The introductory general biology course is usually the first science course for most college students. This course proves to be a pivotal one at the point in which most students choose to pursue a science or non-science major. Most large colleges and universities offer several alternative courses to meet the various needs of the students they service. This study deals with a comparison of two introductory general biology courses that are designed for students considering a science major.

Over a three year period the two courses were compared on a variety of measures. The study took place at a large eastern university and had a population of 1500 students. The two courses presented two totally different approaches to the teaching of general biology. The one was sponsored by a NSF Comprehensive Aid to Undergraduate Science Education grant. Senior faculty from the microbiology and physiology departments were responsible for a live lecture format that emphasized biochemical and molecular biology. A heavy emphasis was placed on the laboratories which were designed to give a "hands on" contact with the "work horse" instruments of modern biological research. The labs were equipped with the type of modern instrumentation that is not usually present in introductory courses. The second is a traditional general biology course which is run by the botany and zoology departments. It employs television lectures with discussions led by graduate teaching assistants. The laboratories are run by the graduate assistants and follow the usual botany-zoology approach.

During each of the three years of the study a somewhat similar design was used. It was modified several times to include new instruments to further the validity of the research. Each year all the students involved in both courses completed a questionnaire that had been designed to give pertinent background information as well as scores for science interest and attitude and scores in science knowledge. During the first two years the scores were used to determine a matched sample from the larger course to be compared to the entire population of the NSF sponsored course. In the third year all students participated in the entire evaluation process. The sequence of the evaluation after the questionnaire included a biology knowledge pretest, an attitude pretest, a propositional logic test, a knowledge posttest, and attitude posttest. The SAT Math and Verbal scores were obtained for the sample.

The results were subjected to statistical analyses such as T-Tests, Analysis of Covariance and Item Analysis. In each of the three years the results showed that the course taken by the students did have a main effect after adjustments for initial differences. The NSF sponsored course students exhibited a better performance on the biology post test in all three years. So it would seem that this course did have a positive effect on the students.

Further research into the causes of this increased learning might prove to be beneficial because of the role that general biology plays in the future choice of major by college students.

Session B-2

ARAB SCIENCE TEACHERS' ATTITUDES TOWARDS TEACHING SCIENCE BY INQUIRY IN SECONDARY SCHOOLS IN ISRAEL

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The goals of this study were: (1) to detect whether or not and to what extent Arab secondary school science teachers in Israel hold positive attitudes towards teaching science by inquiry, (2) to find out if positive attitudes towards inquiry are related to 14 independent variables clustered in three categories; a - variables related to teachers' personal background, i.e. age, sex, etc.; b - variables related to teachers' professional background, i.e. years of teaching, grades, academic degree; and c - variables related to teachers' education, i.e. academic studies, in-service training, etc.

Research Design

The sample consisted of 192 Arab secondary science teachers of biology, chemistry and physics. Most of the teachers taught in rural schools. They answered two questionnaires: 1. Personal Data Form (PDF), which solicited information for 14 independent variables. (2) Inquiry Science Teaching Strategy (ISTS) developed by Lazarowitz and Lee (1976) which consisted of 40 items aimed at detecting the extent to which teachers' attitudes are positive towards the inquiry method.

The ISTS used a 1 to 5 points Likert scale; 20 positive items were valued 5-1, and 20 negative items 1-5, respectively.

Validity and Reliability

Since ISTS was used in the past with American teachers (Lazarowitz and Lee, 1976) and Israeli teachers (Lazarowitz and Tamir, 1980), the instrument was content validated for the use with Arab science teachers and its reliability was calculated by a split half procedure, which yielded a value of .89.

Procedure

Data were collected by three specially trained students who visited the schools and asked secondary science teachers to complete the two questionnaires.

Factor analysis and analysis of variance (including Scheffe techniques) were used.

Factor analysis revealed three factors

1) Conservative approach in teaching science;
2) The inquiry approach in teaching science; and
3) Support of conformatory laboratory instruction.

Results

Generally the ISTS attitude scores reflected that Arab science teachers did not hold positive attitudes towards inquiry. On the contrary, they tended to support the traditional expository method.

However, when the ISTS was analysed per item (and not factors) on 12 items, the Arab teachers expressed some positive attitude towards inquiry.

The background variables of the teachers affected their attitudes slightly. It is worth mentioning that teachers who studied History and Philosophy of Science as part of their university education showed significantly more positive attitudes towards inquiry.

Discussion

During the last few years three teacher samples in different cultures were investigated, using the ISTS and the background form. A cross cultural perspective is suggested. United States teachers generally showed the most positive attitudes towards inquiry and background variables such as: education, academic background, sex and years of teaching were significantly related to their attitudes. The Israeli Jewish sample of teachers was similar to the American sample. The Arab Israeli sample was very different. Their attitudes were more negative towards inquiry and the background variables were not related to their attitudes.

The results suggest a relationship between the degree of traditionality in the society as a general system and science teaching in the classroom. Arab teachers are functioning in a traditional society which is now on the threshold of modernizing.

Conclusions

The main conclusions drawn in this direction are that unless the training programs for Arab teachers take into consideration the teachers' specific personal and socio-cultural backgrounds, their effectiveness will be questionable. In other words, not only considerations stemming from subject matters and universal discussions of methods and techniques, but also those stemming from teachers' backgrounds and the set-up in which they will function should be emphasized.

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Session B-2

ACADEMIC ACHIEVEMENTS, LEARNING ENVIRONMENT, SELF ESTEEM, AND INQUIRY SKILLS OF HIGH SCHOOL STUDENTS IN BIOLOGY TAUGHT IN COOPERATIVE-INVESTIGATIVE SMALL GROUPS

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The goals of this study were to determine the effects of a cooperative-investigative learning approach on academic achievement, self esteem, learning environment and inquiry skills of high school biology students.

This learning approach, which is based on the jigsaw method as described by Aronson (1978), uses a cooperative-investigative way of instruction in small groups. In this study it was hypothesized that the cooperative investigative learning approach in small groups will help students

(1) to increase their motivation to learn, obtaining higher achievement.
(2) to increase their self esteem.
(3) to develop skills of cooperation, increase helping behaviour, and assume more responsibility for their learning.
(4) develop inquiry skills, as a result of the investigative approach used in the instructional method.

The Learning Material

For this study two learning units were developed:

(1) "You and the Cell" and
(2) "The Living Plant"

Each unit was divided into sub-tasks for groups of five students, who treated each other as resources.

Procedures

The sample included one hundred and nine tenth graders in biology. The experimental group included fifty students from two classes, and the control group consisted of fifty-nine students from two other classes which were taught in a traditional manner. Students from both groups were poorly motivated to study, had little interest in learning science, and scored below national norm on the General Aptitude Test Battery.

The experiment lasted five weeks. Two biology teachers and two aides were involved in this study. Both groups studied the same learning material, but in two different methods. Questionnaires regarding achievement tests, self esteem, learning environment and inquiry skills were given as a pre- and posttest, and the mean scores were compared for significant differences, using analysis of covariance.

Results and Conclusion

The results of the achievements tests show that the mean percent increase of the experimental group, was higher than the mean percent increase of the control group, when pre- and posttest mean scores were compared. The test items were categorized by their cognitive level (questions related to knowledge, comprehension, analysis and evaluation).

On self esteem, the results show no significant differences, but on learning environment, the experimental group had higher scores than the control group in all categories related to skills of cooperation, helping behaviour and responsibility.

When comparing group results regarding inquiry skills, it was found that the experimental group developed more of these skills.

The results show that when poorly and low motivated students are involved, the method of cooperation combined with the investigative approach in small group instruction could be one of the ways with which students could be helped. Since this is the first time that cooperative investigative small group instruction based on the jigsaw method was used in biology at the high school level, more studies are needed in order to support our results on a broader base.

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Session B-2

ISRAELI STUDENTS' CONCRETE AND FORMAL THINKING ABILITY AND THEIR ACHIEVEMENT IN MATHEMATICS AND THE SCIENCES

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Introduction

Several attempts have been made by science educators to establish some correlation between students' achievement in science and performance on certain Piagetian tasks as measured by a pencil and paper test (Tisher and Dale, 1975; Longeot, 1965).

This paper is a report of pilot research on the relation between students' thinking ability and their achievement in mathematics and in the sciences (biology, chemistry and physics) in 9th and 10th grade classes.

For this purpose Lawson's (1978) test of Formal Reasoning was administered. This study could also be considered as a revalidation of Lawson's study in a different culture and different educational system.

Methodology

Lawson's (1978) pencil and paper test of formal reasoning was administered in two 9th grade (N = 66) classes and in two 10th grade (N = 63) classes. The test consists of 15 items covering the following Piagetian tasks: 1) conservation of weight; 2) displaced value; 3) proportional reasoning; 4) controlling variables; 5) combinational reasoning and 6) probability.

Teachers' scores (on a 4-10 scale) in mathematics, physics, biology and chemistry were used as a measure of student achievement in the various subjects.

Results and Discussion

Means and standard deviation for grade and gender on Lawson's test were compared by a two way analysis of variance procedure. It was found that 10th grade students scored significantly higher than 9th grade students. Similar results were obtained by Lawson's study in the United States. This could be regarded as an evidence for the validity of the test.

Boys scored significantly higher than girls. However, no interaction, grade x gender, was obtained.

On the bases of a frequency distribution three levels of thinking ability (Lawson's test) were identified.

Level	Score (on Lawson's test)	N
I	0 - 8	34
II	9 - 12	60
III	13 - 15	35

One way analysis of variance procedures were used in order to compare students' mean achievement scores in mathematics and in science according to the levels of thinking ability.

In general, it was found that level III students scored significantly higher than those who are in levels I and II. No differences were obtained between levels I and II. This last finding raises a question concerning the sensitivity of Lawson's test.

Summary

In his article Lawson suggested that in the future similar pencil and paper tests could be used by teachers in their own classrooms. On the basis of our results there is a need to conduct further research in this area.

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Session B-2

A COMPARISON OF BIOLOGY TEACHING IN JUNIOR AND SENIOR HIGH SCHOOLS IN ISRAEL

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The study was designed to compare classroom transactions in junior and senior high school biology classes in Israel and to identify relationships between classroom conditions, lesson format (recitation, laboratory, integrated) and instructional activities. In addition, the validity and reliability of a new instrument, the Structured Lesson Report Form (SLRF), was examined.

The SLRF consists of two parts. The items in the first part are structured and require selection of an appropriate option, as related to students' description, classroom setting, seating arrangement, students teaming, use of audiovisual aids, teacher and students enjoyment, special features of laboratory, inquiry and homework. The second part asks the teacher to describe in her own words what happened in the lesson: questions asked, activities performed and sequence of events. The teachers' anecdotal descriptions had been analyzed into categories and all the data were coded and analyzed by computer programs to yield frequency distributions, means and standard deviations and correlations. The results were analyzed separately for junior (N =155) and senior high (N = 50) classes.

A high level of agreement (80%) was obtained between teachers' self reports and outside observers. Following are some of the results: These are reported as percentage of lesson in junior and senior high classes respectively: Students read from text book in class (20%, 8%). Students had a homework assignment to read from the textbook (13%, 10%) and to answer questions from the textbook (17%, 5%). Laboratory exercises from the textbooks were used by most classes (55%, 69%). The dominant modes of instruction were: teacher led whole class discussion (86%, 78%), teacher explanations (76%, 28%), posing a problem (76%, 29%). Laboratory work was characterized by four activities: designing experiments (36%, 45%), performing experiments (51%, in both), pooling results (35%, 23%) and discussion (80%, in both). Different biological fields were represented as follows: physiology (25%, 48%), biochemistry (19%, 10%), ecology (7%, 4%), genetics (3%, 13%), morphology (14%, 10%), behavior (2%, 0%), evolution and development (4%, 6%). The dominant instructional aid was the chalkboard, followed by charts and diagrams. Very little use was made of other audiovisuals. Inquiry learning occurrence was as follows: to some extent (20%, 26%); to a moderate degree (32%, 20%); to a great extent (27%, 25%). Most teachers reported that both they and their students had enjoyed the lesson. The study provides additional data and interesting differences between laboratory, recitation and integrated lessons. In spite of certain differences the general picture of teaching biology in junior and senior high biology classes is that of inquiry-oriented laboratory-based learning led and guided by the teacher with only medium dependence on the textbook. SLRF was found to be a reliable, valid and useful research and feedback device.

Session B-3

SCIENCE MATERIALS: OPEN VS. DIRECTED INSTRUCTION

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The main purpose of this investigation was to examine whether a more directed involvement with science manipulatives has a greater effect on the development of projective spatial abilities than a non-directed type of involvement.

One-hundred and twenty fifth grade students were randomly assigned to one of four groups, each with N=30. There were 63 female students and 57 male students.

All four groups received instruction consisting of access to manipulatives (SCIS-2nd edition, Rand McNally). Level 5, Energy Sources was used. Activities were chosen on the basis that they would provide the greatest potential for manipulation.

Two fifth grade teachers taught the groups, each having responsibility for one group receiving non-directed instruction and one group receiving directed instruction. Instruction was provided twice a week, 45 minute periods, for six weeks.

A Battery of six Piagetian-type tasks, designed to examine six of the projective groupings suggested by Piaget (IGP_1; IGP_2; IGP_3; IGP_4; IGP_5; and IGP_6) were used. These tasks were administered to one half of the students randomly selected before instruction began, and again to all the students at the end of the instructional sequence.

The experimental design was the Solomon Four Group Design. A 2 x 2 analysis of variance was employed. This analysis yielded an F-statistic which was not significant at the .05 level, and therefore it was concluded the main and interactive effects of pretesting were negligible. An analysis of variance, pretest scores being the covariate, yielded a significant F statistic at the .05 level.

The basic educational implication was that since the role of experience, that is, manipulating materials is a significant factor in many elementary science programs, it seems that a worthwhile course to follow is an examination of specific types of behaviors teachers should encourage their students to pursue with manipulatives. The identification of the specific types of behaviors would entail further investigation concerning the development of other groupings, in both the logical and infralogical subsystems. If the findings of subsequent studies do identify specific types of behaviors as being superior in enhancing the development of groupings, then these behaviors can be incorporated into science programs. It is conjectured by this author that if this procedure does yield positive effects by enhancing the development of groupings, this would be reflected in elementary-age children becoming more competent in doing and understanding science, both in the area of comprehending the content, as well as becoming more conversant with science-type processes.

Session B-3

QUESTIONS IN THE NARRATIVE OF SCIENCE TEXT: DO THEY MAKE ANY DIFFERENCE?

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The purpose of this research was to determine the relative effects of certain question types when these questions were interspersed through the reading passage of textual materials for students in university introductory biology. It was hypothesized that students reading a passage on biology concepts with specific types of interspersed questions would comprehend and retain no more of that passage than students reading the same passage without interspersed questions.

The sample consisted of all 383 students enrolled in a one-semester general biology course during the spring semester 1981 at a large midwestern university. The sample was randomly sorted into six treatment groups of approximately equal size. Early in the semester 54 students read 2769-word passage on the concept of multicellularity taken from a popular university general biology textbook. A second group of 75 students read the same passage except that 24 rhetorical questions were interspersed through the passage at the beginning of selected paragraphs. A third group of 53 students read the passage with factual or recall questions substituted in the same position as the previous rhetorical questions. A fourth group of 79 and a fifth group of 61 students read the passage with hypothesizing and valuing questions respectively placed similarly in the passage. A final group of 61 students did no reading whatsoever.

The dependent variable was a 20-item test given to all students at three different times: immediately after reading the passage, two weeks after reading, and nine weeks after reading. For the testing period immediately after reading, none of the mean scores of the groups reading with questions differed significantly from mean scores of the no-questions group. For the testing period two weeks after reading, all groups reading with questions had mean scores which were significantly lower than the no-questions group (t-values of 3.21, 3.36, 3.83, and 3.62 respectively). In each of these cases the groups reading with questions scored lower. At nine weeks after reading, both the rhetorical-and the valuing-questions groups scored significantly lower than the no-questions group (t-values 3.60 and 2.34 respectively).

As a check on whether reading the passage under any conditions had an effect upon understanding of multicellularity, mean scores of the groups reading the passage were contrasted with scores of a group of students who did not read the passage. Students not reading the passage took the tests at the same intervals as the reading groups. Groups not reading the passage had significantly lower scores than the groups reading the passage in all but three cases: (1) the factual questions group at two weeks ($t = 2.25$, $p \leq .015$), (2) the rhetorical questions group at nine weeks ($t = .94$, $p \leq .19$), and the valuing questions group at nine weeks ($t = 1.65$, $p \leq .05$).

Students do appear to make significant learning gains from reading biology text, especially if such learning is measured within a short period of time (up to two weeks). These data show, with few exceptions, consistently higher tests scores for the groups reading a passage about multicellularity concepts compared to groups not reading the passage.

It appears that understanding and retention of biology concepts due to reading is not enhanced by frequent questions of any kind interspersed in the passage at the beginning of selected paragraphs. In many cases, inserted questions resulted in less learning, particularly over mid- and longer-range time intervals.

Session B-3

IMPROVING READING COMPREHENSION OF CHEMISTRY TEXTBOOKS USING POSTQUESTIONS

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Postquestions have proven to be a powerful technique useful in helping students identify important information contained in narrative reading material. Previous research studies have shown that students can be induced to learn critical characteristics of concepts when using these questions presented subsequent to segments of prose material. However, few researchers have evaluated this technique as it relates to science education, classroom textbooks and comprehension level achievement. The purpose of this study was to investigate the learning and instructional effects of postquestions on helping students to focus their attention on categories (e.g., reaction identification) of information contained in chemistry texts, while helping students learn this textual material in different ways.

The effectiveness of postquestions was examined in terms of four interactive and two main effect hypotheses. An extensive pilot study was conducted to ensure the development of adequate chemical texts and questions. Subsequently, 109 students participated in the experiment. These tenth and eleventh grade students are enrolled in chemistry at three rural senior high schools near Calgary, Alberta. They were randomly assigned to one of six groups; one placebo-control group, one reading-only control group, and one of four postquestion groups. These latter groups read a chemistry text interspersed with postquestions measuring knowledge or comprehension. The postquestions focused students' attention on one of two categories of information. This arrangement permitted the evaluation of the four interactive hypotheses containing postquestions and posttest items requiring students to process different categories of information at different levels of cognition. Specifically, students in these groups were presented a series of five training (instructional) passages each followed by one of four kinds of postquestions. Review of the text was prohibited. The dependent variable was the learned information found in a sixth transfer passage and was evaluated using a posttest consisting of all four types of postquestions used during instruction (training).

As predicted, students' treatment and posttest scores significantly ($p \leq 0.05$) interacted in three of the four conditions (K-PQ , K-PT, K-PQ X C-PT, C-PQ X C-PT, where K = knowledge, PQ = postquestion, PT = posttest, and C = comprehension). Under these conditions students' scores were higher on posttest items from the same category as the inserted questions and lower on posttest items from a different category than the inserted questions. The one exception was the knowledge X comprehension interaction. All scores of students in treatment groups were in the same "range" or significantly higher ($p \leq 0.05$) than the scores of the reading-only control group. Posttest scores of students in all other groups far exceeded the scores of the placebo-control group.

The results of this study suggested that postquestions inserted in a chemistry text can induce a learning set influencing students' attentional processing. Science educators should be aware of the importance of determining which information they most want students to learn and at what level of cognition. Indeed, science educators should put more effort into the design of adjunct questions, thus increasing the chances for learning of criterial information in subsequent material containing study questions.

Session B-4

A STUDY OF CONCEPTUAL CHANGE IN THE CLASSROOM

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Recent studies in cognitive learning have tended to emphasize the role of student alternative frameworks (SAFs -- sometimes called preconceptions or misconceptions). These studies confirm the thesis that learning key science concepts involves a change in previously held conceptions. This cognitive change is a process which is not at all easy to effect and there is considerable evidence that prevalent teaching methods fail to promote it in many students. Although research clearly indicates the importance of SAFs for the improvement of teaching and curriculum, very little work has been done on specific examples of conceptual changes and on the application of these constructs to the development of new teaching strategies.

The purposes of this paper are:

(1) to propose and make a qualitative assessment of a teaching strategy designed to promote conceptual change;

(2) to observe and analyze in detail the dynamics of conceptual change in a number of individual students during the course of a teaching unit on the structure of gases;

(3) to propose a taxonomy of SAFs for the structure of a gas.

The study was conducted in the naturalistic paradigm through observation and analysis of cognitive behavior in a classroom setting. Subjects were sixth grade students in an Ithaca, New York, public school. Their teacher judged them to be of average ability relative to the local school population. They were taught a ten-lesson unit on the structure of gases over a period of four weeks.

The teaching strategy consisted of:

(1) initial exposure of SAFs through their responses to an "exposing event";

(2) sharpening student awareness of their own and other students' alternative frameworks, through discussion and debate;

(3) creating conceptual conflict by attempting to explain a "discrepant event";

(4) encouraging and guiding cognitive accommodation and the invention of a new conceptual model consistent with the accepted scientific framework (SCF).

The data sources were:

(1) a video-recording of five critical lessons;

(2) a written protocol of the remaining five lessons;

(3) student worksheets and questionnaires.

The findings contribute to our understanding of specific cognitive difficulties that students experience in learning the structure of matter in general and the structure of gases in particular. On a more general level, the study presents a model teaching strategy for effecting the conceptual change required in learning many areas of science.

Session B-4

THE EFFECTS OF INSTRUCTION ON INTEGRATED SCIENCE PROCESS SKILL ACHIEVEMENT

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Purpose

The integrated Science Process Skills have been listed as desired outcomes of many exemplary science curricula. Several elementary (e.g. SCIS) middle school (e.g. ISCS) and secondary programs (e.g. BSCS) have attempted to teach students to identify and control variables, state hypotheses and design experiments. Yet recent efforts have shown that neither middle or secondary school students are very proficient in these skills.

In a study just completed, Padilla, Okey and Dillashaw found a significant and high relationship between the integrated science process skills and formal operational abilities (r=.73). This result led to two possible conclusions. The level of formal thinking could be affecting the ability of students to master the integrated process skills. Given the low levels of formal thinking reported among middle and secondary students, this hypothesis does not lend much promise to teaching process skills. On the other hand it could be that teaching science process skills might not only affect process skill abilities but might also enhance formal thinking abilities.

The purpose of this study was to investigate the effect of systematically integrating science process oriented lessons into middle school science curriculum. In addition to process outcomes the effect of the instruction on formal thinking abilities was also studied.

Procedures

Three sixth and three eighth grade teachers were chosen, based on their reputations as effective science teachers. One of four sections of students per teacher was randomly assigned to each of three treatments with two sections assigned to treatment one.

Treatment one - involved a two week introductory unit emphasizing the designing and carrying out of fair experiments. Subsequent content units had approximately one period-long process skill activity per week integrated into the regular curriculum (n=168).

Treatment two - involved only the same two week introductory unit emphasizing fair experiments (n=85).

Treatment three - was a control treatment getting little direct process skill instruction (n=76).

The instructional period lasted for approximately fourteen weeks. All subjects were pretested and posttested on the Test of Logical Thinking (TOLT) and the Test of Integrated Process Skills (TIPS). Previous studies had shown that each test was a reliable and valid instrument for measuring the intended abilities.

Results

Students in the three treatment groups were compared using scores on the integrated process skill (TIPS) and logical thinking (TOLT) tests. In each case, pretreatment scores on the same instruments were used as covariates.

Significant differences were found among the treatment groups on the integrated process skill test. The group receiving extended process skill instructions (treatment one) significantly outscored the other two groups which did not differ in their achievement.

The increased integrated process skill instruction did not, however, have a differential impact on logical thinking outcomes. All three groups increased their scores from pretreatment to posttreatment (perhaps a testing effect) but no differences among groups were evident.

Conclusions

The results of this study can be viewed differently depending on one's point of view. Both differences in achievement and growth in achievement resulted from the enhanced process skill instruction. The concentrated two-week process skill treatment by itself did not have a differential impact. But when it was followed by a systematic attention to integrated process skills in a series of units, achievement was influenced.

The logical thinking skills of students were not much affected in the time span of this study. Either process skills instruction is not a means of influencing growth in logical thinking or the period of time devoted to that pursuit must be extended before effects are evident.

GENERAL SESSION I

THE PRESIDENTS ADDRESS

WHAT SCIENCE TEACHERS SAY TO SCIENCE EDUCATION RESEARCHERS

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INFORMAL SCIENCE STUDY: FIRST-YEAR RESEARCH RESULTS OF SCIENCE IN AMUSEMENT PARKS

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The Informal Science Study is funded by the National Science Foundation to develop instructional materials for middle-school and high school science and mathematics students. Specifically, the IfSS materials are designed to provide introductory, supplemental and advanced instruction in the areas of motion physics by focusing student attention on science and mathematics within informal settings, such as sport arenas, playgrounds and amusement parks.

In 1980-81, the first year of a three-year funding period, six instructional mini-units (designed for two day - three week time periods) were developed and pilot tested in two sites: Houston, Texas and St. Louis, Missouri. In all, some 25 teachers and 3,000 students, grades 5-12, were involved in the pilot testing. The six instructional mini-units are designed around student dialogue, providing introduction and review of physical science concepts in low key, non-technical language. Physical science terms are introduced, as they are needed in explaining real world experiences. In addition, several of the units entail the use of laboratory experiences using toys (race tracks, model rockets....) amusement park field trips (roller coasters...) and the study of sporting activities.

Pre- and post-testing of students in the 1980-81 field testing focused on four major variables:

1. Student recall of past experiences in informal settings.
2. Student knowledge of physical science terms/concepts/principles.
3. Student ability to apply physical science terms/concepts/principles to new problem settings.
4. Student attitude toward science.

Detailed in this paper set are six studies. For each of the studies the dependent variables are the four identified above. Specifically the studies report:

a. The degree to which classroom instruction focused on positive student experiences influences student attitudes toward science as well as their knowledge and application of science concepts.

b. The degree to which students' cognitive style (as measured by the Embedded Figures Test) is related to student gains in IfSS materials.

c. The degree to which utilization of a dialog "storybook" text influences student knowledge and comprehension of science concepts.

d. Pre and post achievement differences between males and females on experience recall, knowledge and comprehension of concepts, as well as attitudes toward science.

e. Development of randomized nested research design for determination of group achievement levels.

Session C-2

THE EFFECTS OF DIRECTED OBSERVATION ON THE LEARNING OF SCIENCE CONCEPTS

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This study investigated the hypothesis that students taught using questioning techniques which directed observation of examples of a concept would achieve higher scores on posttest measuring recall of facts, comprehension, and written and oral production. The subjects were 44 third graders in a rural, predominantly black elementary school. Subjects were randomly assigned to an Experimental treatment group or a Control group. The Experimental group was taught a concept using interactive questioning which directed them in the observation of examples. The Control group was taught the same lesson using the same materials but the presentation was expository. A posttest was administered immediately following each lesson. The Experimental group scored significantly higher than the Control group on the total posttest score and on the written production subtest and oral production subtest. Subjects who were directed by interactive questions to observe the examples were better able to identify pictorial examples of the concept, to demonstrate comprehension of relationships, and to summarize in writing and orally the content of the lesson. In addition, experimental group subjects supplied much more complete descriptions or definitions of the concept being taught, and independently suggested more new examples.

Session C-2

IMPLICATIONS OF INTEGRATED SCIENCE TEACHING UPON STUDENTS' PERCEPTION OF THE DIFFERENT DISCIPLINES OF SCIENCE

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Integrated science teaching is very frequent in the early phases of science education, including junior high school (JHS). On the other hand, in senior high school (SHS) there is a considerable degree of differentiation according to the "classical" science disciplines, and students have to decide which subjects they wish to emphasize in their studies. It is probable that attitudes formed due to JHS science do affect SHS choices, and might have long range implications on career choice. The consequent question is whether integrated science courses in JHS do indeed supply students with the necessary basis for such decision making. This exemplifies one of the problems concerning the need for mutual adjustment among courses, which should be preferably dealt with on the basis of long term studies. This paper presents results relating to one aspect which has been investigated within the framework of a long term study: implications of the integrated nature of science teaching in JHS upon students' attitudes to and preferences for different diciplines of science.

Our multistage research has been going on in Israeli 8th-10th grades since 1977. The results presented are based on data from the first stages, in particular on a cross sectional investigation in 8th and 9th grades (N=1111). The students studied a combined "General Science" curriculum with a high degree of integration between chemistry and physics, and separated biology courses.

The research instruments included a test of interest in science (Meyer, 1969), and specially designed instruments such as attitude questionnaires to chemistry, physics and biology, as well as scales of preference for school subjects.

Factor analytic examinations of the 60 original items, as well as the 6 subject scales a priori suggested in the developing of the test, revealed interesting patterns. These patterns were different from those expected acccording to the "classical" division of science. For instance: physics and chemistry did not appear as distinct areas but loaded on the same factor. Students who took part in courses which were different in content and/or degree of integration exhibited different patterns. Both multi and univariate analyses of attitude scales revealed a close resemblance between physics and chemistry but not with biology.

The results indicate that students encounter difficulties in the differentiation between science disciplines. This was most characteristic of students who experienced highly integrated science courses. We thus believe that the relative weights of the subjects taught in school and the approach adopted (e.g. degree of integration) contribute to the degree of differentiation among science disciplines in the student's mind. This affects the formation of the student's perception of the structure of science, which possibly has further implications upon attitudes to and preferences for different scientific subjects.

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Session C-2

THE EFFECTS OF STRATEGY ANALYSIS ON SCIENCE TEACHER BEHAVIORS: A META-ANALYSIS

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In recent years, the effect of teaching strategy analysis on the behaviors of science teachers has been the focus of many studies. These studies include two main types of analyses: first is the investigation of the influence of analyzing teaching models; second is the investigation of the influence of self analysis. In some cases the focus of this analysis is some type of projected behavior such as questioning techniques or wait-time. In other cases the focus is on the general teacher behavior and is analyzed for such things as the amount of directions or indirectness represented by the activities of the lesson. The dependent variables of interest in these studies usually include some which are closely related to the strategy analysis treatment (e.g., question level, waittime or degree of indirectness). But, some studies include less closely related outcome variables such as teachers' attitudes or their pupils' achievement scores. The purpose of this proposed paper is to review and analyze the results of experimental studies based on science teaching strategy analysis as it affects teaching behaviors. The recently developed statistical procedure of meta-analysis lends itself well to this task.

Meta-analysis techniques are used for condensing and synthesizing the results of a multiple set of empirical studies into an interpretable form. The procedures are quickly gaining favor as a means of making sense of the varied results usually present when one examines numerous studies on a single topic. Meta-analysis techniques are used to calculate a statistic referred to as "Effect-Size." This value is based upon the group means and standard deviations from results of individual studies.

DATA COLLECTION

Both computer and "hand" literature searches were employed in identifying and acquiring studies related to the above purpose. These searches identified a body of studies on science teaching strategy analysis and teaching behaviors which examined a total of 45 dependent variables (additional studies will be added as they are reported). Subjects used in the combined studies numbered over 350 elementary, middle and secondary science teachers.

PROCEDURES

Means for treatment groups were er[illegible]d and standard deviations determined for each study from the repor[illegible]ata. From this information, an "Effect Size" was calculated for each dependent variable.

Data were organized by categorizing all treatments into one of three types:

1. Control, no strategy analysis
2. Treatment I, self analysis
3. Treatment II, model analysis

This yielded a total of 20 self analysis and 25 model analysis effect sizes. A mean effect size was then claculated for each treatment.

RESULTS OF DATA ANALYSIS

Based on the 45 different measures of teaching behaviors, the mean effect sizes for each category were: Treatment I = 1.11 and Treatment II = 1.17.

CONCLUSIONS

The results of meta-analysis indicate that strategy analysis is an effective science teacher training procedure. But, there is no clear indicator as to which method (self or model) is best. As in many cases, one method has the advantage in some contexts while the other is best in a different context.

Session C-3

REDUCTION OF ANXIETY IN PRESERVICE TEACHERS
A SYMPOSIUM

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OVERVIEW

The avoidance of teaching science in the elementary school by the classroom teacher is well documented in the literature of science education (Perkes, 1975; Strawitz, 1976; Barnard, 1977; NSF, 1980). Perhaps, there is a linkage between anxiety about teaching science and the avoidance of teaching the subject.

The researchers were unable to locate any studies which measured anxiety about teaching science in preservice or inservice elementary teachers which might provide "base line" data for subsequent studies. Therefore, the researchers conducted studies examining changes in anxiety about teaching science during a sequence of science content courses designed for preservice elementary teachers. The assessment instrument was the State-Trait Anxiety Inventory. The studies were repeated for four years, during which time both the X and Y forms of the instrument were used. In all four studies anxiety was reduced. However, the pattern varied depending upon staffing arrangements, teaching practices and course content.

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BASIC STUDIES ON ANXIETY IN PRESERVICE TEACHERS

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A six session voluntary workshop (financed by grant monies) combining the use of systematic desensitization and cognitive restructuring methods was designed specifically for helping college students reduce anxiety about teaching science.

Although 80% of the students indicated interest in the preliminary meeting and/or the workshop, only a few actually participated. The most common reason for lack of participation was the difficulty of fitting the workshop into their schedule. The majority of students felt the workshop should be included as part of the course, and given in a laboratory session time frame.

There did not appear to be a relationship between science anxiety as measured by the STAI and student interest in the workshop. Some faculty noted that students they perceived as highly anxious (because of their behavior) did not admit their anxiety and did not attend the workshop.

A FACTOR ANALYTIC STUDY OF THE STATE-TRAIT ANXIETY INVENTORY UTILIZED WITH PERSERVICE ELEMENTARY TEACHERS

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The State-Trait Anxiety Inventory (STAI) has been widely used as a measure of anxiety in the psychological literature. A new form (STAI-Y) has recently been developed and some psychometric data were available from one previous study of Air Force recruits. In order to validate the instrument's use with preservice elementary teachers, a factor analytic study was undertaken.

Preservice elementary teachers (N=103) were administered the self report instrument during a required science course. A restricted principal components analysis with iterations was employed as the factoring technique. A four factor solution accounting for 58.8% of the variance resulted, with a factor loading pattern very similar to the earlier study. This result along with high interval consistency levels support the use of the instrument with preservice elementary teachers.

FACTORS RELATED TO ANXIETY IN TEACHING GEOLOGY

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In a preliminary investigation these researchers noted that students in a lecture section of geology for elementary majors expressed greater confidence in distinguishing between minerals and rocks, and between different categories of rocks than their counterparts in a lecture and laboratory section.

Attempts will be made during the Spring 1982 semester to determine if there is a relationship between anxiety and confidence and if this apparent dissonance can be lessened by training.

Session C-3

AN EXPLORATORY STUDY: STATE ANXIETY AND CONCERNS ABOUT TEACHING ELEMENTARY SCHOOL SCIENCE

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Introduction

A deficit in science teaching appears to be the consequence of many concerns elementary teachers have about science. Science educators have noted that elementary teachers are "frightened" of science, thereby avoiding the teaching of it. Anxiety may play an important role in this avoidance behavior among teachers.

Studies conducted by Westerback (1979, 1981a, 1981b) measured changes in anxiety about teaching science and selected demographic variables of preservice elementary teachers. Studies conducted by Hall, George and Rutherford (1979) and Bethel and Hord (1981) indicate that concerns teachers have about a new practice (teaching elementary school science) or an innovation are identifiable and developmental. There is an apparent void in studies dealing with both anxiety toward science and concerns about teaching science among inservice elementary teachers.

Purpose

The purpose of this exploratory study was to investigate the relationship between anxiety and concerns about teaching elementary school science among inservice teachers.

The study was designed to investigate the following questions:

1. Does a relationship exist between state anxiety and stages of concern teachers have about teaching science?
2. Do stages of concern and state anxiety follow the same pattern of change among inservice elementary teachers?
3. What variables account for the relationship between state anxiety and stages of concern about teaching science among inservice teachers?

The Study

The study involved the administration of the x form of the A-State Scale of the State-Trait Anxiety Inventory (Spielberger, 1970) and the Stages of Concern Questionnaire (Hall, George and Rutherford, 1979) to a group of inservice elementary teachers enrolled in a graduate level course in elementary science.

Procedure

The subjects (N=19) completed the Stages of Concern Questionnaire (SoCQ) and the A-State Scale during the first class meeting and again during the last class meeting after approximately 45 contact hours. Correlation coefficients, t-tests, and multiple stepwise analyses were employed to answer the above questions.

Results

A significant relationship ($p \leq .05$) was indicated between the posttest anxiety scores and the linear composite of the posttest stages of concerns. Stages of concern and state anxiety among the subjects follow the same patterns of change. A difference ($p \leq .05$) does exist between selected pre and post means of selected stages of concern. A similar change in state anxiety was also indicated. A difference ($p \leq .05$) does exist between the means of pre and posttest anxiety scores.

The independent variables -- college semester hours of science, minutes per week teaching science, and the number of years teaching -- contributed most to the relationship between post-anxiety scores and the composite of these independent variables.

Discussion

It appears that state anxiety and concerns about teaching science may be related to a more complex multifaceted set of variables. Subsequent research efforts will attempt to identify, isolate, and investigate variables which may directly affect inservice elementary teachers' anxious state and stage of concern about teaching science.

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Session C-4

EFFECTS OF STUDENT REASONING LEVEL ON POSTTEST FORMAT

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Research on the effects of subjects' reasoning levels on the concrete/abstract nature of the evaluation process in science education is less developed compared to the effectiveness of instruction. The purpose of the investigators in this study was to search for possible differences in subjects' performance on concrete and abstract sections of a posttest that could be attributed to reasoning level. The establishment of such differences could suggest the presence of a reasoning level X test format interaction.

Participants in the study were enrolled in chemistry classes at a large public suburban high school north of Chicago. Thirty-five subjects were classified as 'concrete thinkers,' and another thirty-five subjects were classified as 'formal thinkers,' based on their performance on the Piagetian Logical Operations Test, PLOT. All participants then received the same instructional treatment in a four-week unit on chemical bonding. Instruction consisted of lectures, discussions, and laboratory experiences in which students observed teacher demonstrations with space filling molecular models and actively manipulated the models themselves to study concepts in chemical bonding.

Students were administered a posttest quiz following a segment of instruction on molecular shapes. The quiz contained one section in which students were permitted to construct and manipulate molecular models used during instruction to answer questions. A second section of the posttest required participants to answer questions without the aid of the models.

A check on the PLOT performance of the 'concrete thinkers' and 'formal thinkers' revealed a significant ($p \leq .0001$) difference in their performance. The mean score for the concrete group was 30.17, whereas the mean score for the formal group was 43.23. An ANOVA yielded an F-ratio of 340.9 for 1 and 68 degrees of freedom.

Results of the posttest quiz showed that the 'formal thinkers' did somewhat better than the 'concrete thinkers' on the models section. However, this mean score difference was not statistically significant ($p \leq .05$), as an ANOVA yielded an F-value of 3.292 ($p = .0740$) for 1 and 68 degrees of freedom. Participants' performance on the no-models section of the quiz, however, did reveal the presence of a significant difference ($p \leq .05$) in favor of the group labeled 'formal thinkers.' Due to the brief length (two questions) of the no-models section, a Kruskal-Wallis non-parametric ANOVA was performed on the data. The value of Chi-square, after correction for ties, was found to be 4.328, significant at $p = .037$.

The findings suggest that the reasoning level of subjects may affect the models and no-models sections of the posttest in a different manner. Whereas this study was not designed to specifically determine the presence of a reasoning level X posttest format interaction, its results should be considered as a suggestion that such an interaction may exist. The next step is to design an investigation to evaluate the presence of such an interaction. If such an interaction does in fact exist, then science teachers should be aware of its presence and implications for interpreting student performance.

Session C-4

THE ROLE OF COGNITIVE STYLES IN PROBLEM SOLVING

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Present research in problem solving is conceived of as being primarily concerned with problem solving methods and with degree of knowledge acquisition. A brief argument is advanced that this conceptualization is incomplete because of failure to consider individual differences among problem solvers (other than in problem solving methods and extent of knowledge). A viable theory of problem solving instruction must take into account all three areas. Evidence for the argument is presented in the form of data on problem solving in junior high school students with extreme scores on Within's field independence-field dependence measure of cognitive style.

One hundred fifty randomly selected junior high students in a midwestern city were given individually a series of problems taken from a variety of existing curriculum materials. Each session was audio-taped for subsequent analysis. Student verbal responses form the data base.

The Group Embedded Figures Test was used as the measure of field independence. Tapes of the 20 most strongly field independent and the 17 most strongly field dependent students were chosen for the study reported here. The results indicate that junior high students have difficulty with problem solving - particularly problems involving proportional reasoning or the control and separation of variables. This study also demonstrated that "field independent" students solved significantly more problems than did "field dependent" students. No sex differences were evident.

Session C-4

CREATIVITY AND THE GROUP PROBLEM SOLVING PROCESS

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This study was to determine whether cooperative small groups would stimulate creativity of fifth and sixth grade students more than an individualized learning environment. Creativity was defined as a process of becoming sensitive to problems, identifying the difficulty, searching for solutions, testing and retesting hypotheses, and communicating the results. The term "cooperative small group" refers to a collection of interacting individuals who share a common goal.

Student aptitudes for creative and academic work were assessed on the Torrance Tests of Creative Thinking (Verbal Form A), analysis of student created electrical circuit diagrams, and a batteries and bulbs prediction test. A measure of student perceptions was also used to indicate any changes in attitudes toward the science activity and the learning environment. Trained observers also used Shymansky and Penick's Science Laboratory Interaction Categories to record classroom behaviors.

A posttest control group design was used with 111 fifth and sixth grade students. Half of the population worked by themselves, while the other half (experimental) worked together in groups of four to five students. Each half worked in a student-structured environment on the same science activity which involved creating as many different types of electrical circuits from a given set of batteries and bulbs as possible. It was the same trained teacher who guided students in the individualized setting and in the small cooperative group setting.

Statistical analysis produced the following results:

1. Verbal creativity was not differentially affected by the treatment conditions. This may indicate that the duration of treatment exposure is an important factor when measuring the effects of learning environments on creativity.

2. Verbal creativity was differentially affected by gender and grade. Performance was higher for girls on the fluency and originality tests, and sixth grade students performed higher on all three measures of creativity (fluency, flexibility, and orginality).

3. The small cooperative groups did significantly better on creating electrical circuits than individuals working alone for both the fifth and sixth grades.

4. Understanding of electrical circuits was not differentially affected by the treatment conditions even though the scores indicated both groups of students had a better understanding of electrical circuits from being in the study than from previous experience. Analysis by gender revealed that boys did better in the experimental situation while girls did better in the control group situation.

5. Attitudes measured in this study were not differentially affected by the treatment conditions even though scores indicated that attitudes were more positive in the experimental groups than in the control situation.

In general, fifth grade students were more positive toward both treatments than sixth grade students. An overall conclusion is that fifth and sixth grade students working within small cooperative groups can be more creative with electrical circuits than students working alone. The implication of this study is that small cooperative groups should be used in elementary science classes when creativity is one of the instructional objectives.

Session C-5

WORKSHOP ON INTENSIVE TIME-SERIES DESIGN

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The intensive time-series design has been under development at the Ohio State University since 1975. The design involves the daily collection of data from students in classroom settings over an extended period of time, varying from at least 20 days to as much as 70 days in recent studies. Because of the uniqueness of the design for studying certain types of relationships of interest in science education and of its potential for the daily and continuous monitoring of student understanding and attitudes toward topics, it may be of interest to other researchers in science education.

The first component consists of an overview of the development of the time series design and the rationale for the use of the design. The second component focuses on the mechanisms for collecting data in classroom situations. The third component would be a discussion of the analysis techniques that can be used in dealing with data from time series designs. The fourth and last component would be a discussion of the potential and future for the use of intensive time-series designs including current developments for adapting the data collection to minicomputer or microcomputer use.

To facilitate the use of this design by other researchers, a handbook is being prepared that will:

a. summarize the development and rationale for the design;

b. delineate in detail the data collecting procedures;

c. describe the analysis program and explain the computer output of selected programs.

This handbook will be given to each workshop registrant and forms the basis for the presentations.

GENERAL SESSION II

WHAT INDUSTRY SAYS TO THE SCIENCE EDUCATION RESEARCHER

Session D-1

OVERVIEW: CLASSROOM TEACHING OF SPECIFIC SCIENCE TOPICS

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Science educators have been disappointed in the impact of the science curriculum reform movement that reached its peak in the 1960s. The use of the activity-based programs developed in that movement is declining. Educators usually explain this decline in terms of factors external to the programs: lack of inservice training, lack of materials, faulty materials, inadequate teacher training in the sciences, and teachers' reluctance to teach science in the wake of the back-to-basics movement. Although these are definite obstacles to science teaching, they should not stop educators from taking a good, hard look at the science program materials themselves.

What happens when these external factors are overcome? Do teachers experience the kind of success that will help motivate them to continue to make this effort? What goes wrong when teachers use program materials and how do the teachers cope? Do students have common and consistent difficulties with them?

It is now possible to address these questions using research methods that were virtually unknown to science educators when the science curriculum reform movement was at its peak. Funded by the National Science Foundation, the Planning and Teaching Intermediate Science Project is using some of these new methods to investigate, and ultimately to improve science teaching with available program materials. Following are those methods:

1. Cognitive-introspective methods, which allow us to study and understand teacher planning and teacher thinking as it actually occurs in real school situations (e.g., Clark & Yinger, 1979; Smith & Sendelbach, in press).

2. Methods based on cognitive science that reveal how students perceive and attempt to make sense of mathematical and scientific topics (Davis, 1981; Larkin, McDermott, Simon, 1980; Nussbaum & Novack, 1976).

3. Ecological and ethnographic methods for observing and analyzing classroom instruction (Doyle, 1979; Florio, 1979; and Russell, 1981).

Phase 1 of the project, now complete, involved classroom observations of 18 fifth-grade teachers using either an activity-based program (SCIIS--The Science Curriculum Improvement Study) or a textbook-based program (Laidlaw's Exploring Science). Phase 2, now in progress, is using the results of Phase 1 to design revised versions of the program materials. Phase 3 will test our interpretations through analysis of the use of the revised materials in classroom instruction.

This paper set presents results from Phase 1 of the project. Two of the papers are case studies of teachers, one of a teacher using the Laidlaw program and one of a teacher using the SCIIS program. These papers describe the problems that the teachers encountered as they used the program materials and the ways that they coped with those problems. The other two papers focus on how the students were affected by the classroom instruction they received, with emphasis on the differences between their ways of understanding the topics under study and those of their teachers and the authors of the program materials.

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Paper #1

STUDENT PRECONCEPTIONS INTERFERE WITH LEARNING: CASE STUDIES OF FIFTH-GRADE STUDENTS

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Children's conceptions of a wide variety of scientific topics are markedly different from those of scientifically trained adults. It seems to follow that students' preconceptions about scientific topics will affect the ways that they understand and respond to classroom science instruction. This study examines in detail the relationship between student preconceptions and classroom instruction by constructing "learning stories" of six fifth-grade students as they attempt to make sense of classroom instruction on light and seeing.

Pretests, posttests, and classroom observation narratives served as student data. Three of the six students were from one class and three from another. Both teachers were interviewed. The teachers and students were part of a larger study involving 18 teachers.

The students' pretests indicate that the students held the preconception that we see because light illuminates things; they did not understand the role of reflected light in vision. The posttests indicate that this pattern persisted for five of the six students at the end of the unit. In spite of good teachers using a popular text (Laidlaw's Exploring Science), the instruction was not successful in that conceptual change did not occur. Furthermore, the students' belief in the preconception contributed to their failure to understand other topics covered in the unit, such as the functioning of parts of the eye.

It appears that conceptual change did not occur because student preconceptions were not considered in either the text or classroom instruction. Instead students were taught and learned facts about light and facts about seeing. Many of them had difficulty making sense of these facts, as their answers on the posttest show. The authors hypothesize that to understand the material, students need not only to encounter the scientific conception, but to contrast it with the preconception.

Paper #2

ONE VIEW OF FIFTH-GRADE TEXT BASED SCIENCE INSTRUCTION

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Rationale

This is a case study of one fifth grade classroom using the Laidlaw Brothers Exploring Science textbook. The documentation of text-based science instruction serves as a complement to other case studies of activity-based science instruction.

Methods

Ethnographic methods were employed to observe one teacher and her students as they studied Unit Four of the text (Light). The analysis of the teacher's guide served as a basis of comparison for teacher planning and the instructional process. The planning process was documented by video-recordings with stimulated recall as well as teacher interviews. Actual instruction was observed and audio-recorded for the entire six week duration of the unit. Student seatwork, quizzes and other documentation were also collected. Student conceptions were assessed using pre and posttests.

Results and Implications

This teacher demonstrated a competent and intelligent use of the curriculum materials. In the instruction, students were presented all of the information contained in the text, as well as teacher determined supplemental activities. The teacher demonstrated effective management and effective teaching traits and her ability to motivate students to learn was observed throughout the unit.

The teachers' organizational skills were also observed in the planning process. Her planning procedures were notable in that she gave great attention to learning outcomes of instruction. She accepted the text as authoritative and had established a set routine for instruction for each chapter of the text.

The teacher's overall response to the unit was favorable; she expressed confidence that most students learned a lot. However, the assessment of student conceptual growth indicated that less than half (44%) of students understood basic concepts of light and vision at the end of the unit. Thus the teacher's satisfaction with student learning was only partially justified.

This case study is worthwhile for two reasons: 1) it documents how a highly skilled teacher adapted a unit from a science textbook for use in her classroom and 2) the difficulties experienced by the students raise question about the design of the text.

Paper #3

PLANTS AS PRODUCERS: A CASE STUDY OF ELEMENTARY SCHOOL SCIENCE TEACHING

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This study is part of a larger study investigating teachers' use of program materials in planning and teaching specific science topics. The study's objectives were to:

1. Describe instruction on the topic including similarities and differences compared to the suggestions in the teacher's guide.

2. Analyze the ways in which the teacher's planning and teacher's guide influenced the classroom instruction.

3. Analyze changes in students' conceptions and their relation to instruction.

Information was obtained from analysis of the teacher's guide, video-stimulated recall of teacher planning, classroom observation and audio recording, formal and informal interviews, and pre and post-instruction administration of a test designed to reflect alternative student conceptions.

The study is written as a running account of the course of instruction followed by an interpretive analysis and discussion of implications. The paper is intended to be useful to practitioners as well as researchers.

In her planning, the case study teacher emphasized attention to intended student learning. She included a large portion of the program in actual instruction with the addition of discussions or changes in sequence or content constituting the most frequent kinds of modification.

On the pretest most students appeared to believe that plants do need light to grow, grow better or be healthy, but none demonstrated an awareness of the role of light in photosynthesis. Many students also appeared to think of water and fertilizer as "food" for plants. The teacher expressed surprise and frustration at the persistence of such beliefs. The teacher believed that the activities had not worked because the students had not come up with photosynthesis on their own, even though the teacher's guide anticipated this and called for the teacher to introduce this concept. To overcome these problems, the teacher used audio-visual aids to teach about photosynthesis and what plants need for growth.

On the posttest, about half the class could successfully apply their understanding of the seed and photosynthesis as plants' sources of food. Even these students, however, remained confused as to what food is for plants.

Contributing to the teacher's frustration and the failure of the activities to "work" were:

1) the teacher's unintended modifications of the program's instructional strategy, especially the coordination of certain discussions with available evidence, and

2) the teacher's initial lack of awareness of the students' preconceptions and their tendency to persist.

Both of these problems resulted in part from the content and information overload imposed by organization of the teacher's guide and the way the teacher used it in planning.

The results of this and related studies suggest that problems with activity-based programs themselves as well as external barriers must be overcome if teachers are to experience success in their use. A major problem may be the inadequacy of the teacher's guides to help teachers plan instruction, and especially to help them anticipate and deal with students' preconceptions.

Paper #4

STUDENT CONCEPTIONS OF TWO TOPICS TAUGHT IN FIFTH-GRADE SCIENCE: TEST DEVELOPMENT AND RESULTS

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Learning about science often involves a process of conceptual change. Students must abandon preconceptions in favor of more mature or scientific conceptions. This paper describes the development of group administered tests that assess the degree to which conceptual change takes place in students studying two topics from popular elementary school science programs: Producers (from the SCIIS Communities unit) and Light (from the Laidlaw Exploring Science text).

The tests and analysis procedures were developed through a five-step process. First, teacher's guides from the two programs were analyzed for the purposes of defining the goal conceptions that the students were supposed to understand as a result of instruction. Test items were then developed, and the tests were piloted and revised. The third step was data collection, in which the Light test was administered before and after instruction to about 170 students, and the Producers test was similarly administered to about 250 students. The fourth step was the development of formal descriptions of the most common student preconceptions. Finally, response-coding and scoring procedures were developed which made it possible to distinguish (a) students who believed the preconceptions, (b) students who understood and believed the goal conceptions, and (c) students whose answers were inconsistent or confused.

Results indicated that before instruction students' beliefs were dominated by preconceptions. The most important of these preconceptions are contrasted with the goal conceptions defined in the program in Table 1.

Table 1: Contrasts Between Common Student Preconceptions and Goal Conceptions

Issue	Common Preconception	Goal Conception
Light		
1) How do we see it?	Light shines on or brightens objects so that our eyes can see them directly.	Our eyes detect reflected light that has bounced off objects around us.
2) What is color?	Color is something that can be added to either light or objects around us. Light reveals the color of objects.	Color (wavelength) is a property of light. Objects appear colored because they reflect some colors of light while absorbing others.
Producers		
1) Where do plants get their food?	Plants get their food from the soil in the form of water and/or	Sprouting seeds use food stored in the cotyledons. Mature plants use light to make their own food.
2) Why do plants need light?	Plants need light to stay green and healthy.	Plants use light energy to make their food.

Posttest results indicated that the beliefs of most students were affected by instruction. However, students who came to understand and believe the goal conceptions were in the minority. More common were students who retained some or all of their preconceptions. Evidence of confusion or contradiction in students' belief systems was also common on the posttest.

These results are significant for two reasons. First, they add to the literature on children's conceptions of scientific topics. Second, the tests provide a means of assessing the effects of instruction at a deeper and more meaningful level than is normally done. In this case, the test results shed doubt on the effectiveness of the SCIIS and Laidlaw program materials, as actually used, for promoting conceptual change.

Session D-2

INVESTIGATING LEARNING MEDIATORS IN THE PLANETARIUM CLASSROOM

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The purpose of the investigation was to compare the effects of advance organizers and clustering as mediators of learning in lessons presented at a planetarium. The comparisons of the treatments were made at various ability track levels in order to compare interaction effects.

This investigation examined effects of mediators on learning in the planetarium. A related question posed by this investigation asked if design of the instruction can aid lower ability track students in reaching performance levels comparable with students of higher academic ability.

The scheme of the study was a nonrandomized pretest/posttest design with senior high school students in an intact school system as subjects of the study.

Thirty six class sections including 832 students participated in the investigation. Nine class sections were randomly assigned to each treatment; therefore, there were three class sections from each of the three academic track levels assigned to each treatment. The control treatment groups were instructed without the benefit of the learning mediators, clustering, or advance organizers. The other treatments included groups instructed with benefit of clustering, advance organizers, and a combination of these mediators of learning.

The instrument used for the pretest and posttest was designed by the investigator for use in a 1978 preliminary study comparing these treatments in the planetarium. The internal consistency was established through the Kuder - Richardson 21 formula. The content validity was established by a faculty committee representing all departments at Hempfield Area Senior High School.

An analysis of variance was conducted with the means of the posttest scores to investigate treatment effects of academic level, and interactions. The general linear model was performed to further study regression and interactions. Treatments and levels were compared by the Duncan method. Individual treatments and levels of academic track were compared by the Scheffè method.

The treatment group receiving both clustering and advance organizers in the instruction preformed significantly higher on the posttest then any other treatment group; however the clustering treatment and the advance organizer treatment each produced significantly higher performance than the control treatment.

The investigation produced data that indicate that the multiple use of mediators of learning can significantly improve learning outcomes of planetarium presentations.

Studies that have reported planetarium learning to be dependent on characteristics of the teacher should be questioned in light of the information gathered by this study. This investigation determined that one teacher utilizing different mediators of learning can bring about significantly different learning outcomes.

Session D-2

ATTENTION AND CURIOSITY IN INFORMAL SCIENCE SETTINGS

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Two hundred and thirty-eight museum visitors of all ages were observed as they entered the Object Gallery area of the Florida State Museum. Visitors were observed under conditions where objects were available for close inspection, but could not be manipulated (baseline data) and later when the same objects were placed on tables and were available for visitors to touch, move, and use a variety of senses to inspect them (intervention data). Data were recorded on the number, sex, age and time So spent in this area under each of the above conditions.

The results obtained show a significant increase in the number of visitors entering this section of the museum when manipulatable objects were available. Baseline data showed that 58.5% of the people who entered the Object Gallery went into the drawer section. However, when manipulatable objects were present, this increased to 82.3%.

Chi square analysis was used to determine whether entering the drawer section depended on age or sex. It was found that more children entered the drawer section than adults ($p. \leq .05$) and more male children entered than female children ($p. \leq .05$). Chi square analysis was also used to determine whether the presence of manipulatable objects in the area increased the number of people who entered this area. They did! ($p. \leq .05$). It was also found that the total time spent in this section did not increase from the baseline to the manipulative treatment. However, the time children spent in this section did increase when manipulative objects were readily available.

These data are supported by considerable curiosity research indicating that both children and adults are attracted to novel as well as complex stimuli which can be manipulated in both formal and free-choice environments. The data also support the growing movement to hands-on exhibits in natural history museums and science centers around the country as well as hands-on classroom activities from the perspective of their attention attracting and holding power and their curiosity invoking characteristics. Whether these positive factors also lead to increased knowledge or skill development is a question yet to be explored!

Session D-4

THE IDENTIFICATION AND REPRESENTATION OF STUDENT KNOWLEDGE CONCERNING DENSITY

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The problems of learning science facing Western and non-Western students are fundamentally the same. For both, the problem concerns conceptual change from existing knowledge, i.e. knowledge accumulated from everyday experiences to new scientific knowledge, i.e. formalised knowledge concerning natural phenomena. The difficulties experienced by non-Western students are greatly magnified by factors such as their cultural and religious beliefs, social and physical environments and language. Nevertheless the findings of this cross-cultural study have implications for both Western and non-Western science education. In this study an attempt has been made to identify and represent the knowledge structures of a particular group of students in a particular subject area, namely density, and to compare the identified knowledge structures with those involved in the orthodox scientific version of density.

The study includes a description of the use made of these knowledge structures by representative students in solving the problem of why some objects float and others sink in water. The issue of the role played by the ability to use relational thought versus the possession of appropriate knowledge structures in solving problems is discussed in the context of the results in this study.

Session D-4

CHILDRENS' ALTERNATIVE FRAMEWORKS ABOUT MOTION

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A study was conducted in which tasks from Piaget's work on movement and speed were modified and adapted to the class task format. Groups of children of ages 7 to 12 in England and Canada were given the tasks and the results analyzed. All attempts at assigning developmental levels failed, both in the present study and a previous related one by Adey.

The children's acquisiton of the the concepts did not correspond with Piaget's work or with Lovell's. Reversibility, intuition of speed, and the understanding of relative movement and distance were attained considerably later for both groups of children. Concepts of acceleration were not understood until after age 11 for most children. These findings have support from Robertson's and Richardson's research on time, speed and distance.

The data from this study were subsequently re-analyzed using the children's incorrect responses as well as the ages at which most children understand the concepts of motion. From this information hierarchies of acquisition of concepts of motion for the sample of English and Canadian children were developed. It was also noted that the children's incorrect responses were similar through the ages of seven to twelve until they finally gained the correct understanding.

The findings of this study agree with the 'alternative frameworks' proposal of Driver which states that children develop their unique reasons for phenomena they do not understand. The importance of this concept is that teachers must find out what alternative frameworks the children possess before they proceed to plan instruction.

Session D-4

STUDENT UNDERSTANDING OF CHEMICAL EQUATION BALANCING

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Fourteen high school chemistry students from two different schools were interviewed in depth on how they balanced simple chemical equations, the knowledge they employed while balancing the equations, and their representation of the balanced equations with diagrams. The equations were of the type employed when students are first introduced to chemical equation balancing in high school.

All students were able to successfully balance the four equations presented to them. However, seven of the twelve students were not able to construct diagrams which were reasonably consistent with the notation of the balanced equation. It was further noted that these same students possessed very poor understanding of the concept of the chemical subscript and were willing to violate the balancing rule which states that subscripts are not to be changed while balancing equations. The five students who were able to make consistent diagrams also possessed good concepts of subscript and the balancing rule.

Session D-4

CAN STUDENTS BE TAUGHT BY ANALOGY?

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Although the literature is replete with claims about the facilitative effects of analogies on reasoning and learning, few empirical studies have been able to substantiate these claims. Despite their potential as classroom learning aids, analogies have not been widely implemented because of the lack of consensus as to what analogies are and how they should be appropriately used in instruction.

A model has been proposed for systematically designing and validating instructional analogies. The model also serves as a means for clarifying the conflicting conceptions and divergent assumptions about analogy function that exist in the educational literature. The model allows selection and/or creation of analogies for different content areas and different learning outcomes. The model is based on the theory of qualitative analogy attributes. Analogies are theorized to have five inherent characteristics: familiarity, imageability, meaningfulness, relevance and complexity. Familiarity is the amount of prior exposure to the concepts and relations in an analogy. Meaningfulness is the amount of information contained in the analogy. Relevance is the degree to which the analogy information forms an ideational link to instructional content. Complexity is the expansiveness of the analogy; i.e., how far it can be elaborated. The model provides a means for assessing the potential contribution of an analogy to the learning outcome.

Session E-1

OVERVIEW:

A META-ANALYSIS OF MAJOR SCIENCE EDUCATION QUESTIONS

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The recent appearance of meta-analysis has provided a useful tool for integrating and interpreting the results of science education research. While this technique is being applied to a variety of specific science education questions, it has the potential to provide even more information if applied to the totality of existing science education research. Such an approach is possible if the integrative review of research focuses upon the major research questions in the field, gives appropriate attention to the subquestions subsumed under each major question, and provides for integration of data on the variables that pertain to two or more of these major questions.

Such an endeavor has in fact been conducted with financial support from the National Science Foundation. Within the conceptual framework described above, approximately one thousand research studies have been integrated, and the results provide the basis for a compendium of interpretative and integrative statements about the major questions addressed in the science education research literature.

The questions addressed were as follows:

I. What are the effects of different curricular programs in science?

II. What are the effects of different instructional systems used in science teaching (e.g., programmed instruction, mastery learning, departmentalized instruction)?

III. What are the effects of different teaching techniques (e.g., questioning behaviors, wait-time, advance organizers, testing practices)?

IV. What are the effects of different pre-service and in-service teacher education programs and techniques?

V. What are the relationships between science teacher characteristics and teacher behaviors or student outcomes?

VI. What are the relationships between student characteristics and student outcomes in science?

The actual coding and analysis work was conducted by researchers located at seven different research centers across the United States. At each site an individual or a team of up to three researchers conducted the work. Prior to the beginning of this work, all of the researchers involved attended a week-long session for training and coordination of efforts. This paper describes (1) some of the overall characteristics of the science education literature identified in the project and (2) the consistency in findings across the several meta-analysis questions in those instances where there are related areas.

One result of the project was the clear identification of dissertations as the best source of information rather than journal articles, when the findings have been reported in both forms. In this project microfilmed copies of dissertations were used for the meta-analysis in all cases where the research had been conducted as a dissertation project. Although they take much longer to code, the data contained in such sources are much more complete, so that dissertations are far better sources of information.

Various summary tables are presented which are based on the other papers in this paper set and show the consistency of findings across the several individual research endeavors.

Session E-1

Paper #1

THE EFFECTS OF NEW SCIENCE CURRICULA ON STUDENT PERFORMANCE

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Elementary, junior high, and secondary school science experienced a tremendous curriculum development and growth beginning in the late 1950's, through the early 1970's, that can be described only as phenomenal. The public became very science and technology conscious following the historic launching of Sputnik I by the Soviet Union on October 4, 1957. Numerous "alphabet-soup" science curricula were developed to rekindle student interest in science and to upgrade the apparent lethargic science curriculum in the schools. Since the inception of the NSF sponsored curriculum development era there have been numerous evaluation efforts to assess the impact of the new curricula versus traditional science courses. The question as to whether the newly developed curricula were any "better" than the traditional courses became a leading issue in science education.

The large body of research on the effects of the new curricula is generally viewed as inconclusive. A brief scan through the literature reveals that some studies claim that the new curricula facilitate cognitive and/or affective achievement while others claim they do not. After 25 years of sporadic implemenation and more than 5 billion dollars spent on K-12 science improvement (Yager, 1981), the question of how effective new science curricula actually are in enhancing student performance is still unanswered.

This study sumarizes the results of a quantitative synthesis of the retrievable primary research dealing with the effects of new science curricula on student performance. This study synthesizes the results of 105 experimental studies involving more than 45,000 students and utilizes the quantitative synthesis perspective to research integration known as meta-analysis (Glass, 1976). A total of 27 different new science curricula involving one or more measures of student performance are included in this meta-analysis. Data were collected for 18 a priori selected student performance measures.

In addressing the overall question of new science curriculum effectiveness, the data are arranged in three broad categories: curricular characteristics, student or teacher factors, and study design features. The variable analyzed in all cases is student performance measured in terms of the meta-analysis common metric known as effect size.

The results of this meta-analysis reveal definite positive patterns of student performance in new science curricula. Across all new science curricula analyzed, students exposed to new science curricula performed better than students in traditional courses in general achievement, analytic skills, process skills, and related skills (reading, mathematics, social studies and communication), as well as developing a more positive attitude toward science. On a composite basis, the average student in new science curricula exceeded the performance of 63% of the students in traditional science courses.

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Session E-1

Paper #2

A META-ANALYSIS OF RESEARCH ON PRE-SERVICE AND IN-SERVICE SCIENCE TEACHER EDUCATION PRACTICES DESIGNED TO PRODUCE OUTCOMES ASSOCIATED WITH INQUIRY STRATEGY

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This study examined the discrepancy between educators' expectations for inquiry behavior in teachers and the actual status. A quantitative assessment of the existing research on training outcomes, teacher inquiry behaviors and the techniques and procedures used to obtain them was made.

Inquiry addresses those teacher behaviors that facilitate student acquisition of concepts and processes through strategies such as problem-solving, uses of evidence, logical and analytical reasoning, clarification of values, and decision making. The quantitative assessment was undertaken using the method termed meta-analysis wherein an integration of studies is attained by coding the criterion variables and expressing the outcome variables as effect sizes. Because of the variability in the research reports, factors that affect meta-analysis were examined in addition to those associated with inquiry behaviors in teachers. Studies from 1965 to 1977 were located and reviewed.

Studies which contained sufficient data for the calculation of an effect size were coded for one hundred and fourteen variables. These variables were divided into the following six major categories: study information and design characteristics, teacher and teacher trainee characteristics, student characteristics, treatment description, outcome description, and effect size calculation. A total of sixty-eight studies resulting in 177 effect size calculations were coded. Mean effect sizes broken across selected variables were calculated and correlation and analysis of variance were used to investigate relationships among criterion and outcome variables.

The effect sizes measured on teachers were distributed as follows: sixty-two from journal articles, eighty-four from dissertations, and seven from unpublished sources. Analysis of variance of the effect size means associated with these sources was significant at the .05 level. Ninety of the above effect sizes were associated with outcomes consistent with inquiry strategy and resulted in a mean of 1.054 and a standard deviation of 1.547. Strong correlations existed among many of the criterion and outcome variables and further enumeration of mean effect sizes across variables of interest was presented.

The method of calculating the effect size and the source of the means used for the calculation were each found to contribute less than one percent to the variance of the sample. The form of the document supplying the information for the effect size calculation correlated with effect size significant at the .002 level and the measurement method correlated with effect size at the .007 level.

If other studies support the findings of this study, some of the practices used in meta-analysis may be strongly questioned.

Session E-1

Paper #3

A META-ANALYSIS OF TEACHING SYSTEMS IN SCIENCE

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This paper is a report of a meta-analysis on the question: "What are the effects of different instructional systems used in science teaching?" The following definition was employed:

> An instructional system is a general plan for conducting a course over an extended period of time. It is general in that it often encompasses many aspects of a course (e.g., presentaton of content testing, size of study groups). Examples of instructional systems are: mastery learning, competency-based instruction, programmed instruction, modular instruction, mini-courses, ability grouping, team teaching, departmentalized versus self-contained, diagnostic-prescriptive instruction, independent studies/ projects, computer-managed or computer-assisted instruction, audio-tutorial.

The studies utilized in this meta-analysis were identified by a process that included a systematic screening of all dissertations completed in the field of science education since 1950, an ERIC search of literature, a systematic screening of selected research journals, and the standard procedure of identifying potentially relevant studies through examination of bibliographies of studies reviewed.

The final coding sheet employed consisted of the following eleven sections, each with a number of coding variables:

(1) identification of the study;

(2) student identification (treatment group: control group);

(3) context characteristics (treatment group: control group);

(4) teacher characteristics (treatment group: control group);

(5) design characteristics (treatment group: control group);

(6) treatment characteristics (treatment group: control group);

(7) features (treatment group: control group);

(8) group structure (treatment group: control group);

(9) materials (treatment group: control group);

(10) outcome characteristics;

(11) effect size calculation.

In all, the 130 studies coded gave rise to 341 effect sizes distributed over the years 1950 through 1980, with the bulk of effect sizes being obtained in the years 1961 through 1974. The mean effect size produced over all systems was 0.10 with a standard deviation of 0.41, indicating that, on the average, an innovative teaching system in this sample produced one-tenth of a standard

deviation better performance than traditional science teaching. Mean effect sizes were also computed by year of publication, form of publication, grade level, student assignment to groups, subject matter, type of outcome criterion, origin of instrument used, method of data analysis, as well as type of teaching system.

Session E-1

Paper #4

A META-ANALYSIS OF THE IMPACT OF DIFFERENT SCIENCE TEACHING TECHNIQUES ON STUDENT ACHIEVEMENT

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Objectives

This study is a meta-analysis of the question "What are the effects on achievement of different teaching techniques?" Twelve categories of teaching techniques were specified. Among these are questioning, wait-time, testing, focusing, manipulative, presentation approach, inquiry or discovery, audio-visual and teacher direction.

A quantitative overview of how teaching techniques and other important variables are associated with student achievement has important implications for teaching as well as research. This is accomplished through meta-analysis.

Methods

Reports and documents in the science education literature were collected and examined to determine features of the studies (e.g., number of students, content area, context characteristics) and the effects of the techniques used. A coding form was then developed to allow for the uniform examination and recording of 76 variables from each study.

The coding process involved examining each selected study to determine and record values for as many of each of the variables as possible. One or more effect sizes were calculated and coded for each study. In this investigation the effect size is a standard measure of the difference between an experimental teaching technique and a traditional method.

To compute effect size when comparing an experimental teaching technique to a control method, the mean of the control group is subtracted from the mean of the experimental group and then divided by the standard deviation of the control group. A study results in multiple effect sizes when there is more than one experimental treatment or when there are two or more post measures.

Data Sources

Initial selection of studies for coding was based on title. Over 300 microfilmed dissertations covering the past 30 years were selected and provided by the ERIC Center at Ohio State University. Some 2000 ERIC science abstracts were reviewed and suitable studies were obtained locally on microfiche. Finally, article titles were reviewed in all issues of the Journal of College Science Teaching, the Journal of Research in Science Teaching and issues of Science Education, 1970 and later. The bulk of the studies involved subjects from grade six to college freshman.

Results

A total of 411 effect sizes representing 160 studies were produced for the question "What are the effects on achievement of different teaching techniques?" The mean effect size overall was 0.336 with a standard deviation of 0.414. Thus, for all samples considered the experimental science teaching techniques on the average resulted in one-third of a standard deviation improvement over traditional techniques.

More than 20 other variables such as class size, community type and science subject area were cross-tabulated with effect size.

Conclusions

The meta-analysis of the impact of different teaching techniques is part of a concerted effort to examine seven areas of science education judged to be of sufficient importance to justify an effort to integrate the research. The findings of this effort can provide a valuable data bank for practitioners, researchers and other decision makers.

Session E-1

Paper 65

A SYNTHESIS OF RESEARCH CONCERNING INQUIRY TEACHING AND ADVANCE ORGANIZERS IN SCIENCE EDUCATION

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This study involved the coding of 128 characteristics for 72 studies which spanned the period from 1956 through 1980. The coding variables included 57 which were concerned with features of the treatment while 12 were concerned with outcome attributes. Aspects such as research methodology, sample characteristics, and instructional experiences were examined quantitatively in terms of their relationships to the treatment effects through the use of a common metric for all studies as defined by Glass (1978).

Three areas of research were explored: the comparison of the inductive vs. deductive approach, the use of advance organizers, and the level of inquiry of the learning experiences. The data analysis procedures involved the use of the exploratory data analysis methodology (Tukey, 1977). Exploratory data analysis has the potential for clarifying interrelationships and giving direction to the science education research effort. The intent was thus to formulate implications and questions for further research and to provide directions for research programs through the refinement or expansion of the research effort.

The discovery of relationships between effect sizes and study characteristics involved the comparison of effect sizes across the levels of each descriptive variable for each of the three defined research topics. This included the review of correlation coefficients across study characteristics, the examination of study design characteristics in relation to effect size, and treatment characteristics in relation to effect size.

This meta-analysis for the research variables examined may provide a foundation for the continued exploration of learning and teaching in science education. The results of this analysis have influenced the formulation of conjectures concerning treatment effectiveness and have provided needed information for establishing methodological and investigative directions for future research.

It is hoped that the coding variables formulated for this study can provide a beginning framework for the design and communication of research characteristics in future studies. The lack of descriptive information in the coded studies resulted in the inability to explore complex interactions and the effect of confounding variables not addressed in individual studies.

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Paper #6

A META-ANALYSIS OF THE TEACHER CHARACTERISTICS, TEACHER BEHAVIORS AND STUDENT OUTCOMES IN SCIENCE

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The question addressed was the relationship between teacher background characteristics (gender, coursework, IQ, etc.) as the independent factor, and: (1) their teaching behavior in the classroom (questioning behavior, teaching orientation, etc.); and (2) student outcome characteristics (achievement, attitude toward science, etc.) as the two dependent factors.

The population under study was science classes, ranging from kindergarten through twelfth grade, located in the United States, and the teachers of these classes.

The studies coded under this question came from three sources: dissertations, journal articles, and unpublished articles stored on microfiche.

Protocol for Coding

1. The statement of the problem addressed by an article was reviewed to see if the study actually fell within the boundaries of the question. If the study pertained to the question at hand, it was given a study number.

2. In dissertations, the methods chapter was referenced to find descriptions of instruments used, the composition of the sample, and the statistics used.

3. The chapter relating study results was then consulted to code reported statistics. All statistics were converted to Pearson product moment correlations. If the statistics reported were in a form that would require a high degree of manipulation to report in the form of a Pearson correlation, the appendices were referenced to see if raw data were reported. If statistical manipulation was required, notes were made at the end of the coding sheet.

4. Difficulties in coding were carefully noted so that procedures for solving these difficulties could be referenced when they were again encountered in subsequent studies.

Analysis

Use was made of the SPSS package. The data were first sorted into criteria that related to student outcome and to teacher behavior. Data were then sorted by the values of the criterion variable within each of the strata (student outcome and teacher behavior).

For each value of the criterion variables, a test was made to check whether a specific teacher characteristic had been studied as correlating with the criteria. If a correlation was reported for that teacher characteristic (a specific predictor), the correlation was reported along with several contextual variables of the study, and an average calculated of all those studies in a category relating a specific criterion with a teacher characteristic.

In general, quite low relationships were found between teacher background characteristics and (1) their teaching behavior in the classroom and (2) student outcome characteristics. Summary tables showing all the relationships have been prepared and will be presented.

Paper #7

WHAT ARE THE RELATIONSHIPS BETWEEN STUDENT CHARACTERISTICS AND OUTCOMES IN SCIENCE?

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A meta-analysis procedure was employed by researchers at the University of Colorado to study relationships between student characteristics and student outcomes in science. The investigation concentrated on three main areas of student characteristics: academic ability, personological factors, and personality characteristics. The study was restricted to only those investigations conducted with kindergarten through twelfth grade students in the United States since 1940.

The search process for locating relevant studies involved review of: published dissertation titles and abstracts, research summaries, entire collections of science-related journals, referrals of articles from other universities, and computer-generated searches. A total of 169 studies was coded for the project. Of these, 72% were dissertations, 24% were journal articles, 3% were from fugitive documents, and 1% were from NAEP data. Although NAEP data accounted for only 1% of the studies, it accounts for a much larger proportion of the data base. Data for personological factors were analyzed with and without inclusion of the NAEP data for comparison.

In addition to reporting these data, an attempt was made to determine whether results were consistent across several factors. To this end, data were collapsed in several ways: content and level by cognitive variables, content and level by affective variables, and level by specific criterion measures.

The data were also organized by criterion types listing the best predictors of each student outcome. For instance, the strongest relationship determined by the present study was a correlation between elementary science achievement and Verbal SAT scores ($r = .68$) followed closely by a correlation between elementary science achievement and language ability ($r = .48$).

Generally speaking, the strongest predictors of student outcomes in science were found among the various measures of academic ability. This was followed by personality characteristics and, finally, personological factors. It should be noted that even the weakest relationship between student outcomes and personological factors is of interest. The use of the effect size measure for these factors has enabled the present authors to show not only the direction but also the strength of these relationships. Generally speaking, the relationships between race, SES, or sex and students' outcomes have shown small but very consistent differences favoring whites, high SES, and males. However, interesting exceptions to these trends have been noted, particularly in the area of affective measures.

After pursuing a large number of studies related to student characteristics and science outcomes, the authors are prepared to comment on the state of the literature. Topics of consideration are: the quality and organization of studies and how this affects the ability to code them in a meta-analysis form; the time period during which most studies on a particular topic have been investigated; suggestions for further research; and suggestions for others interested in conducting meta-analysis.

THE EFFECT OF WAIT TIME FEEDBACK ON TEACHER-STUDENT INTERACTION IN CLASSROOM DISCUSSION

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Wait time, the duration of teacher pauses after questions, is an important variable in research on science teaching. This project investigated the effects of increasing teachers' wait times on general questioning skills in science teaching. In previous research, the influence of wait time training has been confounded with instruction in general questioning skills, making it difficult to test the hypothesis that increasing the wait time will by itself improve classroom discussions. In this project, these variables were separated through the use of four treatment groups made up of science teachers. One group received instruction in wait time using a newly developed electronic feedback device that monitors the duration of teacher and student pauses; a second group received instruction in general questioning skills; a third group received both types of instruction; a comparison group received no instruction of either type. Audio tape recordings of classroom interaction were analyzed in terms of teacher questioning behavior (including wait time as well as other variables) and student responses.

Printed materials produced only a slight increase in the teacher's wait times. The use of the feedback devices caused the teachers to increase their wait times significantly. Interaction effects were also significant, favoring those who had access to the devices without the additional complication of reading the written materials. Treatment effects were maximized at the fifth week of the project, then diminished as the end of the school year approached. The greatest change in behavior that was noted in the analysis was the amount of time that students were able to actively participate in discussions.

Session E-2

...ST A COLLEGE TEACHER DO RESEARCH?" AND OTHER AXIOMS

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In higher education a teacher implies a researcher (CUEBS, 1969). Numerous studies indicate the criterion used most frequently for promotion is research productivity (Hayes, 1971; Siegfried and White, 1973.) But what, if any, is the relationship between teaching and research? Must a teacher publish or perish? Or does research detract from teaching? Can persistent axioms be endorsed statistically?

The current study quantified some of the relationships that exist between publications, grants and teaching effectiveness. The study was conducted in the science departments of two different universities. The sample consisted of 157 men and women who had been promoted in the ten years from 1969-1979. Pearson product-moment correlations were used.

A significant relationship between student evaluations and publication evaluation is reported ($r = 0.26$). No significant correlation was found between student evaluations and other measures of scholarly productivity. Significant correlations are reported for publication evaluation vs publication counts ($r = 0.89$); citation counts vs publication evaluations ($r = 0.58$); citation counts and publication counts ($r = 0.51$); publication counts vs grants ($r = 0.38$); grants vs publication evaluation ($r = 0.24$) and citation counts vs grants ($r = 0.20$).

By quantifying data it has been possible to examine persistent axioms and to reach the following conclusions: 1) there is a weak correlation ($r = 0.26$) between publication evaluation and teaching effectiveness; 2) there is a high correlation between the quality and quantity of publications ($r = 0.51$ for citation vs publication count); 3) research activities apparently do not detract from teaching effectiveness; 4) it was possible to obtain a grant without publications; 5) promotions were apparently not more difficult to obtain at the end of the 1970's based on the data categories in this study; 6) not all schools demand "publish or perish."

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Session E-6

THE RELATIONSHIP AMONG TEACHER CLASSROOM MANAGEMENT BEHAVIORS, STUDENT ENGAGEMENT AND STUDENT ACHIEVEMENT OF MIDDLE AND HIGH SCHOOL SCIENCE STUDENTS OF VARYING APTITUDE

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This study was designed to determine the relationship among teacher classroom management behavior, student engagement and student achievement of middle and high school science students. These variables were investigated across varying levels of academic aptitude. Two week long units were taught by 30 experienced science teachers. During this period of time teacher classroom management behavior, student achievement (N = 570), student engagement (N = 269) and student academic aptitude (N = 649) were measured. Twelve selected management indicators from Georgia Teacher Performance Assessment Indicators (TPAI) were used to measure teacher classroom management behaviors.

Regression analysis was used to determine the relationship between the variables, and appropriate post hoc procedures were used. Analyses showed that there was a significant relationship among all variables. Post hoc analysis showed that these results were consistent across levels of aptitude. Other relationships found were between student engagement and achievement, student aptitude and achievement, and student aptitude and engagement. Correlation coefficients were obtained for each individual managment indicator.

Those particular management behaviors which were correlated with achievement and engagement are: identifies students who don't understand directions and helps them individually, maintains learner involvement in lessons, reinforces and encourages the efforts of learners to maintain involvement, attends to routine tasks, uses instructional time efficiently, provides feedback to learners about their behavior, manages disruptive behavior among learners.

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THE DEVELOPMENT AND EVALUATION OF AN INTERACTIVE COMPUTER PROGRAM SIMULATION DESIGNED TO TEACH SCIENCE CLASSROOM LABORATORY SAFETY TO PRESERVICE AND INSERVICE TEACHERS

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The results of this study demonstrate that a computer program simulation was effective in teaching science classroom laboratory safety to preservice teachers. The study also demonstrated that the subjects transferred the ability to correctly recognize and prioritize safety hazards in another simulated science classroom laboratory setting.

The Solomon Four-Group design was used with this study. The design was modified slightly to include a transfer measure immediately following the posttest measure.

The subjects were both preservice elementary teachers and preservice science teachers enrolled in the student teaching field experience program at The University of Texas at Austin, during the Spring semester, 1981. A total of 74 subjects were used in this study.

Data analysis was accomplished by a random effects analysis of variance which produced results in the form of reliability coefficients of the subjects' ranking. Comparison of the response sets for the pretest, posttest and transfer measure determined that a significant confidence level may be placed in the indicated correlation statistics.

The subjects having interacted with the computer program simulation were capable of correctly recognizing and prioritizing the safety situations ($r=.98$). The no treatment subjects were incapable of correctly prioritizing the safety situations ($r=.69$).

Session F-2

COMPUTER-AIDED FORMATIVE TESTING

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Purpose/Objectives

The value of frequent formative tests has been demonstrated in a number of studies. Brief objectives-referenced tests, frequently given, aid both teachers and students in identifying learning problems. Reteaching and restudying efforts can then remedy the problems identified by the tests. Frequent testing, however, places a burden on the teacher. Administering and scoring tests takes time that could be devoted to other beneficial teaching activities. The purpose of this project was to study the effectiveness of using computers to administer and score diagnostic tests in science classrooms.

Procedures

Students in four ninth-grade physical science classes were randomly assigned to four treatment conditions. One group received the regular classroom instruction with summative unit tests given at about two week intervals. The other three groups all received formative (diagnostic) tests twice each week. These three formative tested groups differed in how they were tested. One group took paper and pencil tests and received feedback from the teacher, the second group took paper and pencil tests and checked responses on the computer, and the third group used a computer to take the diagnostic test and to check the answers. Following the tests (whether paper and pencil or computer), students were advised about which objectives they had not achieved and were directed to specific materials to study.

All computer work was done using two Commodore microprocessors in a preparation room adjacent to the classroom. Students worked in pairs at the computer terminals. Each formative test took from 5 to 10 minutes to complete. The study was conducted over a period of 6 weeks. A total of 12 formative tests were given.

At the end of each two-week unit, students in all classes completed a multiple choice test prepared by the researchers on the unit objectives. Scores on these three summative tests and on an attitude measure were used to compare classes.

Results

Based on scores from the three unit tests, no consistent differences in cognitive achievement were found. Students in all groups scored at about the 65% level on the three cognitive tests. Attitude results, however, strongly favored the use of the computers in diagnostic testing and feedback. Almost without exception, students receiving either of the computer-based treatments commented favorably in solicited feedback about the experience. Students receiving the paper and pencil diagnostic tests viewed them as helpful although test results showed no effect related to their use.

Conclusions/Implications

Computer-aided formative testing had no beneficial impact in this study even though students and the teacher were enthusiastic about the experience. Although diagnostic testing has been shown to be generally effective in other studies, that result was not borne out here. The general enthusiasm for the process of computer based testing needs to be translated into careful use of formative test results in order to derive benefit from the effort.

Session F-2

A THREE-PART TEST FOR JUDGING THE EVALUATIVE QUALITY OF LIKERT ATTITUDE ITEMS

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Introduction

That which is unique to attitude, when compared to other psychological concepts, is its emotional characteristics. Social psychologists call it evaluative quality--that tendency to be for or against something (Fishbein and Ajzen, 1975). Attitude, this readiness to respond favorably or unfavorably toward an object, is best represented by a like-dislike continuum. A conceptually valid attitude scale, therefore, should have evaluative quality which means that each item will generate data that clusters at each end of Likert's five-point continuum.

Problem

The purpose of this paper was: (1) to design a three-part model for testing the evaluative quality of attitude statements, and (2) to demonstrate the model by applying it to pilot data from select energy attitude items generated by 93 preservice teachers who responded to the trial attitude statements (Koballa, 1981).

1. Bipolar data If an evaluative, pro-con quality is necessary for a statement to represent the attitude concept, data should cluster at both ends of Likert's five-point continuum. Those subjects favorable toward energy conservation should respond with "strongly agree" and "agree" and those opposed should respond with "disagree" and "strongly disagree." Therefore, a distribution skewed in either direction on Likert's continuum makes an item suspect, suggesting that it be rewritten and piloted again or discarded.

2. Neutral data A statement that stimulates emotion will generate data in two polar camps, the pro and con. So the less the responses at Likert's neutral point, the more prone the distribution is to be clustered at the poles. If a high number of respondents are undecided, say more than 30, the neutral responses erode the numbers of the agreement-disagreement ends of our continuum implying low evaluative quality. The item with a high undecided response suggests neutrality of subjects, or an item that lacks clarity. It should be rewritten or dropped.

3. The Validity Index Not only should our pilot data on an attitude statement be clustered at the poles with a low neutral response, the data on each must discriminate subjects with a positive attitude from those with a negative attitude. Subjects with the most positive attitude, i.e., those with the high total score on an attitude scale, should be the ones who respond most positively to a positive attitude statement. And, of course, subjects with a low total score should respond negatively to our positive statement. Item-total correlation provides discrimination data necessary for judging the evaluative quality of an attitude statement. The item-total correlation would be at least .30 (Crano and Brewer, 1973).

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Session F-3

RESEARCH IN INFORMAL SETTINGS - A SYMPOSIUM

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A small but growing number of investigators in the U.S. are becoming interested in conducting research in informal education settings. Museums, zoos, nature centers and aquaria provide a unique environment for studying a wide range of learner behaviors, attitudes and cognitions. Within the last five years, several clusters of informal education researchers (as opposed to evaluators) have developed in semi-isolation in disparate parts of the country. The purpose of this symposium would be to bring together key figures from each of these groups in order to initiate a substantive dialogue on the issues and directions for research in out-of-school settings.

The National Science Foundation has stated that science education need not, in fact should not, be confined to the public schools. Unfortunately, the numerous organizations that exist outside of the formal education system have traditionally not received much attention from researchers or material developers. This is true despite the fact that many youths spend significant percentages of their time participating in science-related "extra-curricular" activities in informal settings. In addition, numerous testimonials suggest that these intensive, free choice associations within informal educational organizations can have a profound influence on career decisions. Many scientists pinpoint their "apprenticeships" at museums or nature centers as being instrumental in guiding their ultimate decisions to become scientists.

Attendance at science centers in the United States has recently exploded, and other informal settings have described comparable booms. Informal settings differ in many significant dimensions from formal school-based educational settings. By its very definition, informal education is neither compulsory nor strongly evaluative. The participants are, by and large, there because they want to be and they are performing for their own self-satisfaction. As a result, people in informal settings are more likely to be receptive to new ideas and activities. They have the expectation that the experience will be inherently enjoyable or that they can do things to make it enjoyable. Informal education settings are ideal environments for investigating a wide variety of basic science education research concerns and issues.

Each panel member will briefly outline past, current, and future lines of research. Topics to be discussed in the symposium include:

a) factors leading up to and influencing problem solving behavior in informal settings;
b) setting effects on learning, the role of environmental novelty on cognition and behavior;

c) factors that influence learners' attention in museums and science centers;
d) the role of advance organizers in influencing learning, specifically within a school field trip context;
e) changes in cognition and affect as a function of informal education experiences;
f) investigations into mental imagery and its contribution to learning in object-oriented settings;
g) curiosity and its contribution to learning in informal settings;
h) cognitive gains from museum experience versus comparable classroom experience;
i) male and female differences in behavior in informal settings; and
j) pedagogical practices of volunteers or educational personnel.

Session F-4

ENERGY KNOWLEDGE AND ATTITUDES AND LOCUS OF CONTROL OF SECONDARY TEACHERS

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The purpose of the study was to measure the energy knowledge and attitudes and locus of control between the participants of a DOE faculty development workshop on alternate energy sources and a control group.

The 100 item Energy Inventory (Glass, 1979) and Environmental Q-sort (Humphreys, 1975) were utilized to determine the energy attitudes for both groups. The Rotter Internal-External Locus of Control Scale (1966) was administered to the participants and a control group.

Pre-test data were collected from 38 secondary teachers (23 science teachers, 10 social studies teachers, and 5 industrial arts teachers) who participated in the DOE program. The Energy Inventory and Q-sort were administered on the first day of the program (July, 1980). For the Energy Inventory, each subject responded to the 100 items as either yes, no, or I don't know. For the Q-sort, the subjects arranged 50 adjectives from the most positive to most negative. A control group (N=9) was randomly selected using one course of the existing graduate summer course offerings. All subjects completed the same three instruments.

Data were analyzed by SPSS (Nie, 1975). Prior to the workshop, the participants in the DOE workshop had significantly greater knowledge about energy than the control group. The internal DOE participants showed a significant correlation between the Q-sort score (both pre and post). The workshop participants who utilized biomass for either primary or secondary home heating had a significantly greater knowledge, as measured by Energy Inventory, than non-wood users prior to the workshop.

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Session F-4

THE EFFECT OF A PERSUASIVE COMMUNICATION ON THE ENERGY ATTITUDES OF COLLEGE STUDENTS

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The Problem

The purpose of this investigation was to compare the attitudinal effect of a placebo treatment with a systematically designed persuasive communication using Hovland, Janis, and Kelly's four-part model, "Who says what to whom with what effect," in changing the energy attitudes of college students preparing to become elementary teachers.

Question Central to the Study

Does a persuasive communication modeled after Hovland's approach result in a positive attitude change and does that communication resist dissipation weeks later?

Procedure

A pretest, posttest, delayed-posttest, control group design was used with subjects randomly assigned to either treatment or placebo group.

The sample, 120 preservice elementary school teachers, represented Hovland's "whom" component of the model. The investigators administered the attitude instrument as a pretest to the subjects enrolled in classes at an eastern university. Three weeks later, the subjects received either the treatment or placebo, both via videotape.

1. The placebo consisted of a 13:10 minute presentation on siphons. The videotape in no way eluded to the perceived importance of energy conservation, making it a viable selection for the placebo.

2. The treatment consisted of a persuasive communication, the core of which was seven belief statements about the importance of energy conservation in the elementary school curriculum. The duration of the treatment was 13:25 minutes.

Immediately following the presentation of the videotapes and three weeks later, the attitude scale was readministered by the investigators.

Results

The results indicated that the systematically designed persuasive communication was significantly more effective than the placebo in changing and sustaining attitudes toward energy conservation.

Conclusions

1. A short, systematically designed persuasive communication can change the attitudes of college students toward energy conservation.

2. The attitude change did not dissipate as shown by a delayed posttest given three weeks after the treatment.

Session F-4

THE DEVELOPMENT AND USE OF ENERGY KNOWLEDGE AND ATTITUDE TESTS FROM RELEASED NATIONAL ASSESSMENT ITEMS

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Statement of the Problem

Can valid and reliable measures of energy knowledge and attitudes be developed from NAEP released items? Can these tests be successfully used to evaluate inservice teacher energy workshops?

Rationale

The investigators were interested in evaluating cognitive and affective outcomes of a Department of Energy faculty development workshop. A review of the research was unable to identify any valid and reliable energy tests specifically designed for adults.

Procedures

The items used to develop the tests came from NAEP Booklet 4 given to young adults during the 1976-77 National Assessment of Educational Progress survey. The purpose of the NAEP survey was to indicate what portions of students successfully achieved various objectives. Therefore, the grouping of NAEP items used in the survey did not contain a priori validated affective and cognitive scales which could be used outright as criterion measures. The groupings for both affective and cognitive items appeared "content" valid. However, the question of whether the items in the various a priori groupings actually formed separate factors had to be examined. In addition, the question of reliability of the groupings in term of their scale had to be investigated.

After validity and reliability analysis using NAEP Data (N=1,300) the scales were used in an evaluation study.

Results and Conclusions

The instruments were able to identify significant pre to post gains in energy knowledge by participants enrolled in a summer energy workshop (N=22). Significant changes in attitudes were also measured.

Results indicate that these evaluation instruments, developed from released NAEP items, can be used as valid and reliable measures of teachers' energy knowledge and attitudes.

VALIDATION OF THE TEST OF ENERGY CONCEPTS AND VALUES FOR HIGH SCHOOL STUDENTS

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The purpose of the study was to develop and validate an energy education test that would be appropriate for secondary school.

The National Assessment of Education Progress administered a 146 item test to young adults (ages 26-35) in 1977. This test, Energy Assessment Awareness Among Young Adults, had both a knowledge about and attitude towards energy actions. This test was reviewed and inappropriate items were deleted prior to administration. The test edition of Test of Energy Concepts and Values consisted of 39 attitudinal items and 35 knowledge items. The split-half reliability for attitude section was 0.795 and for the knowledge section was 0.754.

A factor analysis was done on the attitude and knowledge sections separately. One significant factor, accounting for 25.4% of the variance, was found for the attitude section, and one significant factor, accounting for 31.1% of the variance, was found for the knowledge section.

An item by item comparison between the Test of Energy Concepts and Values and the National Assessment test was made using a pre and posttest design with a total of 350 students in grades 7-12.

Session F-5

CONDUCTING CONTEXTUALIST RESEARCH IN SCIENCE EDUCATION

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This two-hour research methods workshop is intended to provide participants with an introduction to issues and techniques associated with contextualist research in science education. The workshop includes an overview and bibliography of some recent contextual research in science education, but special attention is given to two critical questions:

1. Where does one find appropriate analytic categories for contextual research?

2. How does one ensure precision in the application of selected categories?

Specifically, the workshop builds on the arguments and analyses reported in Roberts (in press); Munby, Orpwood, and Russell (1980); and Roberts and Russell (1975). Working with participants in small groups, the workshop leaders provide illustration and practice in the development and application of perspectives for analyzing contextual data. Classroom events, science textbooks, and curriculum policy deliberations are among the examples considered.

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Session G-1

CLASSROOM BEHAVIOR, CAUSAL ATTRIBUTIONS AND ACHIEVEMENT OF URBAN JUNIOR HIGH SCHOOL SCIENCE STUDENTS

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Method. A systematic observational study of pupil classroom behavior was conducted in five desegregated urban junior high schools. Subjects were 80 students, equally divided by race and sex, drawn from 10 classes taught by 5 teachers. Two subjects of each race and sex were chosen at random from each class.

Observational data on student behavior were collected by means of a previously developed on-site multiple category coding system. Trained observers coded the behavior of one student at a time using 14 categories of behavior. Each subject was observed for a total of 60 minutes during ten six-minute periods.

Entering scores on the SRA reading and math tests were used as measures of ability. Final course grade was used as the achievement measure.

Data on causal attribution of success and failure were obtained by means of an Attribution Scale (Fennema, Wolleat, and Pedro, 1979) adapted for science.

Results. Behaviors were combined into three categories: Active Learning, Passive Learning and Non-attending. Correlations of odd-even behavior frequencies showed classroom behavior to be a stable characteristic of individual students.

Behavior frequencies were approximately equal in the three categories; i.e., two-thirds of the class time was spent in active or passive learning activities. There were not significant differences by race or sex in any behavior category.

Analysis of variance showed a significant main effect for race, favoring whites, on SRA math, SRA reading, and final grade. There was no main effect for sex on any of these measures.

A significant positive correlation was found between Active Learning and final grade and a significant negative correlation between Non-attending and final grade. SRA math score was the best predictor of final grade, followed by SRA reading. When the effects of these scores were removed, Active Learning was the only variable that significantly increased the variance accounted for in final grade.

There were no main effects for race in causal attribution but there were significant sex differences in attributions of success to ability and effort. Boys attributed success in science to their own ability while girls attributed it to effort. There was no correlation between attribution and actual effort as measured by Active Learning.

Although teachers were not observed directly, two pupil behavior categories (listening in a group, and disengaged while teacher is talking) gave a measure of teacher control and convergence as opposed to student independence. The five sets of classes (two per teacher) were categorized on this dimension. Those classes intermediate between the two extremes had the lowest frequencies of student nonattending behaviors and the highest frequencies of students who attributed success to classroom environment.

Significance. The results suggest that the causes for sex and race differences in achievement in science are not to be found in differences in overt classroom behavior. All students exhibited active learning behaviors and there were no significant sex or race differences. The high correlation between final grade and entering math and reading scores indicates that students

who lack these skills have a poor prospect for a good grade in science but some of the disadvantage can be overcome by effort, since time spent in Active Learning behavior is also a significant predictor of final grade. The effect of sex differences in causal attribution is not clear since causal attribution was not correlated as expected with observed behavior.

Overall, the results offer some encouragement for the use of activity-centered science curricula in desegregated classrooms.

Paper #1 - Rationale and Objectives

Rationale

Three consecutive national surveys of science achievement (National Assessment of Educational Progress, 1978) have found that white students score higher than black students at all three age levels tested and that males score higher than females at all age levels.

The reasons for these differences have not been determined. It is well known that a significant proportion of the variance in achievement is accounted for by differences in socio-economic status and IQ, but these leave a substantial proportion of variance unaccounted for. The purpose of this study was to determine whether some of the group variance in achievement can be explained by differences in classroom behavior and/or causal attributions of success and failure. The relation of classroom organization to these variables was also examined.

Common sense suggests that achievement should be related to classroom behavior. Pupils who spend more time in on-task or learning activities would be intuitively expected to learn more than pupils of equal ability who spend less time engaged in such behavior. Research in this area has been extensive but supports the anticipated positive relationship between behavior and achievement (Hoge and Luce, 1979; Centra and P ter, 1980). We have sought to determine whether there are sex and/or race differences in classroom behavior and whether classroom behavior is significantly related to achievement for junior high school science students.

Another factor that may be related to achievement is causal attribution of success and failure. There is some evidence that girls are more likely to attribute success to effort, and failure to lack of ability, and that boys are more likely to attribute success to ability (Rogers, 1980). There is also some evidence of differences between black and white children, with white children judging ability and effort as the most important factors in success and black children judging luck and difficulty of the task as more important (Friend and Neale, 1972). We have sought to determine whether there are race and/or sex differences in this factor and whether causal attribution was correlated with the actual effort expended in the classroom, as measured by the frequency of active learning behaviors.

Objectives

The objectives of this study were (1) to observe and characterize student behaviors in racially integrated, activity-centered science classes at the junior high school level, (2) to determine the relationship of behavior to race and sex, (3) to determine whether behavior is a significant predictor of achievement after removing the effect of standardized math and reading test scores, (4) to determine whether significant race or sex differences exist in causal attribution of success and failure in science, and (5) to determine the effects of classroom organization on student behavior and causal attributions.

Paper #2 - Method

Setting

The study was conducted in Syracuse, New York, a city with a population of about 200,000 in a metropolitan area of about half a million people. Syracuse is an old industrial city with a mixed ethnic population. About 40% of the present school population are members of a minority group, mostly black. Desegregation has been achieved by busing and redistricting. Most of the youngsters now in the junior high schools have always attended desegregated schools. While the average socioeconomic status of the black population is

probably lower than that of the white population, there is a growing black middle class and there are also many white children whose families are poor.

Sample

Eighty subjects, evenly divided by race and sex, were drawn from ten classes taught by five teachers. Five urban junior high schools with black-white student ratios between sixty-five and thirty-five percent were identified. One science teacher in each school was selected on the basis of (a) agreeing to use informally structured, activity-centered teaching methods, and (b) having two classes that each contained at least two black girls, two black boys, two white girls, and two white boys. All five teachers were white; one was female. The average class size was twenty-five students.

Class rosters were obtained for each class with names identified by race, sex and daily attendance record. After eliminating from the rosters students who had been absent for more than five days in the present semester, two black girls, two black boys, two white girls, and two white boys were drawn at random from those available. The final sample contained twenty subjects in each of the four race by sex categories.

Observational Instrument

Data on student behavior were collected by means of a previously developed on-site multiple category coding system.

Observers were trained first by coding behavior observed on videotapes and then by coding behavior observed in classrooms. A minimum inter-observer reliability of 85% agreement with a criterion observer was required before data collection began. Two subsequent reliability checks were made during the course of the observations.

An observer recorded the behavior of one student at a time, coding the subject's behavior(s), the race and sex of the students with whom the subject interacted, and whether the subject initiated the interaction. Interactions with the teacher were coded and recorded, but the teacher was not observed directly. Each subject was observed for ten six-minute segments. The observers carried small battery-powered tape recorders that signalled, via one earphone, five seconds for each observation followed by seven seconds for recording. Each subject had two observers who were responsible for five observations each, made on ten separate school days.

All behaviors were coded into one of the following exhaustive and mutually exclusive categories:

Preparing/returning (Pr) - gathering and returning materials; sharpening pencil; walking specifically necessary for gathering and returning materials.

Waiting (Wa) - waiting for the teacher's attention; waiting for teacher to check notebook or quiz.

Observing (O) - watching another's performance of experiment or task; listening to a discussion between other students.

Experimenting (E) - purposeful physical manipulation of apparatus.

Discussion (D) - talking about performance of a task with peer, teacher, or group; questioning; follow-up of questions; information giving; answering teacher's questions.

Reading/Writing (Rw) - using textbook; recording data. Does not include taking group test.

Copying (C) - copying information without having had any input into its formulation.

Listening (L) - listening to teacher give explanation to class as a group.

Conversing (Cv) - talking about subjects unrelated to class tasks (+ or -)*

Touching (T) - hitting; jabbing; hugging; tapping; putting hands on, etc. (+ or -)*

Disengaged (Dt) - out of contact with people, ideas, classroom situation; daydreaming; looking around the room at other people, not related to task.

Disengaged (Ta) - not listening while teacher talks to class as a group.

The coding system made it possible to code all observed behaviors and to code each observed behavior in one category only.

After an initial introduction to the classes and explanation of the project, observers slipped in and out of classrooms almost unnoticed. Only the observers knew the identity of the subjects until all observational data collection had been completed.

At the end of each observation the data for each student were summed for each category and subsequently entered into a computer to be held until needed for data analysis.

After the completion of observational data collection all students in each class were administered the Attribution Scale and related questions. SRA math and reading scores from the preceding fall and final course grades were obtained after the close of the school year from school records.

Correlational analysis, analysis of variance, and multiple regression analysis were employed to answer the research questions.

*Two behavior categories.

Paper #3 - Behavior and Achievement

Data

The data provided by the observational instrument consisted of frequencies of occurrence of each behavior during each 6-minute time sample for each subject.

Analysis of Classroom Behavior

The frequencies of occurrence of each behavior during 60 minutes of observation was calculated for each subject. Analysis of variance showed no significant difference between black and white subjects on any of the 14 behaviors. This replicates a previous study in which all subjects were male and is an interesting finding, since it refutes the view that black youngsters are more aggressive, more "physical" and apt to engage in fewer learning activities (cf. Smith, 1978, p. 97).

There were no sex differences in behavior frequencies except for one behavior -- waiting for the teacher -- and the boys were more often waiting than the girls. This also runs counter to conventional wisdom, which is that teachers are more prompt in responding to boys than to girls.

With this one rather minor exception, there were no race or sex differences in behavior.

Stability of Behaviors

In order for behavior to be a useful variable in making predictions or establishing relationships, it has to be shown to be a stable characteristic of the learner under the conditions studied. Since the 14 categories of behavior included some that had very low frequencies and were not exhibited at all by some subjects, behaviors were collapsed into three categories as follows: Active Learning, Passive Learning, and Non-Attending.

Frequencies of these behaviors were then calculated for each subject for each 6-minute observation period. Correlations between odd and even observations for each of the main behaviors were 0.69 for Active Learning, 0.59 for Passive Learning, and 0.64 for Non-Attending. The totals for these three categories of behavior were used in subsequent analyses. A 2 x 3 analysis of variance yielded

no significant main effects for sex or race and no significant interaction. The evidence seems clear that girls participate as actively as boys in science classes and that there are no behaviors that distinguish between black and white youngsters.

Ability and Achievement

The school administered SRA math and reading tests early in the school year. These scores were used as indicators of academic ability for science. The final course grade was used as the measure of achievement. Analysis of variance showed a significant main effect for race, favoring whites, on SRA math, SRA reading and final grade. There was no main effect for sex. The final grade and SRA scores were intercorrelated for all groups.

Behavior and Achievement

Regression analysis was used to determine whether classroom behavior accounted for variance in final grade over and above the variance accounted for by SRA scores. Analyses were carried out on the total sample and for each subgroup. In all cases SRA math score was the best predictor of final grade, followed by Active Learning and SRA reading. Passive Learning and Non-attending behavior were negatively correlated with final grade. Some of the data are given below.

1. Correlation Matrix

	Grade	SRA Math	SRA Read.	Act. Lrn.	Pass. Lrn.
Grade	1.00				
SRA Math	0.66	1.00			
SRA Read.	0.51	0.69	1.00		
Act. Lrn.	0.64	0.50	0.25	1.00	
Pass. Lrn.	-0.30	-0.36	-0.25	-0.42	1.00
Non-Att.	-0.28	-0.05	0.03	-0.44	-0.58

2. Summary of Fixed-Order Regression Analysis

	Adj. R^2	Prob.
SRA Math	.43	$\leq .01$
SRA Read.	.45	n.s.
Act. Lrn.	.58	$\leq .01$
Pass. Lrn.	.59	n.s.
Non-Att.	.60	n.s.

The most significant finding, in addition to those previously mentioned in regard to behavior frequencies, was that Active Learning behavior is a significant predictor of final grade for all groups. Much of the research relating time-on-task to achievement has used a measure of the amount of time spent by the teacher in teaching a specific subject. The significance of this finding lies in the use of the pupil as the unit of analysis and the removal of math and reading scores before entering behavior into the equation.

One of the research questions that prompted the study was whether group differences in achievement in science could be accounted for by differences in classroom behavior. Our data indicate that there are no significant differences among the groups in classroom behavior and that behavior accounts for variance among individuals but not among groups.

Paper #4 - Students' Perceptions of the Causes of Success and Failure in Science

One variable that we have found to be related to achievement is the behavior we have labeled Active Learning, a category that represents task-oriented, purposeful behavior or effort. Ability and effort are generally

thought to be predictors of success in school and elsewhere but while ability is relatively stable, effort is not, since it depends on motivation and context.

Two assumptions that have been useful in motivational theory are (1) that effort is directed towards ends or goals that are valued by the individual (reward value), and (2) that effort will be guided by the expectation of success or failure, i.e., causal attribution is a factor in motivation.

The most fully developed theory of motivation based on attribution is that of Weiner (1979) which, in its simplest form, yields four main causes to which success or failure is attributed -- ability, effort, task difficulty and luck. The only one of these variables over which a student has control is effort and the amount of effort expended may depend on the student's belief about what brings about success in that situation.

Previous studies have found that white children judged effort and ability to be more important while black children chose luck and task difficulty (Friend and Neale, 1972). Other researchers (Halperin and Abrams, 1978; Rogers, 1980) have found sex differences in attribution.

We adapted to science an Attribution Scale (Fennema, Wolleat, and Pedro, 1979) developed for mathematics and administered it after the completion of the observational data collection. This instrument yields eight scores for each subject as follows: success-ability, success-effort, success-task, success-luck; and failure-ability, failure-effort, failure-task, failure-luck. Analysis of variance (2 x 2) showed that there were no significant main effects for race in any category but that there were two interesting sex differences. Boys attributed success to ability while girls attributed it to effort. This is particularly strking in view of the fact that there were not significant sex differences in either SRA math or reading scores or in classroom behaviors that indicated effort. We did not find support for our hypothesis that causal attribution would influence classroom behavior except that there were negative correlations between Active Learning and the attribution of failure to lack of ability and to bad luck. It should be noted that those who attributed failure to lack of ability had an accurate perception since they tended to be those with low SRA scores.

Paper #5 - The Relation of Classroom Organization to Student Behaviors and Causal Attributions

The degree of student independence (student-directed behaviors) in the classroom and its effects upon student behavior and achievement is of major concern to science educators. In order to investigate this question an objective measure of classroom structure had to be derived from the data obtained through the observation of students. Specifically, the researchers wished to classify objectively the classrooms as to their levels of student autonomy. If a teacher frequently addresses a class as a whole (i.e., lecturing) it should be obvious that such a class could hardly be considered student-directed. Thus, knowing the frequency of "teacher talk" in a classroom gives one a valuable objective measure of student independence within the classroom.

Conveniently, the behavior categories of "student disengaged while teacher talking" (Ta) and "student listening" (L) yield a measure of how often the teacher addressed the class as a whole. Therefore, a mean value for the sum of the two behaviors (Ta and L) was calculated for each set of science classrooms. (There was one classroom set per teacher, with each set consisting of two classes, making a grand total of ten classrooms.)

Teacher/Classroom Set	Mean "Teacher Talk Per Observation Period	% "Teacher Talk" of Observation Intervals Per Observation Period
1	1.47	4.9
2	6.20	20.6
3	8.41	28.0
4	10.39	34.6
5	15.99	53.3

The five sets of classrooms were placed into three categories: (1) student-centered, (2) teacher-centered, and (3) intermediate. Classrooms with the lowest mean value were classified as student-centered and those with the highest mean value were classified as teacher-centered. Since classroom sets 2, 3 and 4 tended to be tightly clustered, but significantly deviant from the extremes established by classroom sets 1 and 5, they were categorized as intermediate.

Many interesting results were uncovered when the data were analyzed for differences among the various classrooms (teachers). A few of interest will be noted here. The measures of ability used in this study were the scores on SRA math and reading tests. These tests were found to be the best predictors of final grade for our sample of students. However, the correlation of the SRA math and reading subtests with final grade varied with student independence. In the classrooms which were student-centered the SRA math score correlated significantly with student grades while the SRA reading scores did not. Alternately, in those classrooms which were teacher-centered the SRA reading score correlated significantly with final grades, while the math score did not. Furthermore, the apparent trend was reinforced by the findings that both the SRA math and reading scores correlated significantly with final grades in those classes which were classified as intermediate.

Comparisons between classes which were teacher-centered and those which were student-centered showed, as one would expect, that the pupils in the teacher-centered classrooms engaged in significantly less active learning and significantly more passive learning. In addition, pupils in the student centered classrooms engaged in a significantly greater amount of on-task interaction than was found in teacher-centered classrooms. Since cooperative learning has been shown to be useful in improving race relations in desegregated schools (Slavin, 1980), this finding is of particular interest.

An interesting trend appeared regarding the frequency of off-task behaviors. Classrooms with an intermediate student-teacher focus exhibited the lowest frequency of such behavior, while classrooms which were either student-centered or teacher-centered showed significantly higher frequencies of off-task behaviors. Furthermore, a comparison between the student-centered and teacher-centered classes did not yield a significant difference in off-task behavior.

An interesting finding surfaced with regard to student attributions within the various categories of classrooms. Students in classrooms of intermediate student/teacher focus attributed their success in science to the classroom environment at a significantly higher frequency than students in either student-centered or teacher-centered classrooms. In addition, no significant difference between classes of the two extreme sturctures was found on this variable. It appears, therefore, that students believe that an environment that provides an intermediate amount of independence is facilitative to learning.

These results may be relevant to the current popular demand for a return to the more traditional (i.e., teacher-centered) classroom structure.

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A NEO-PIAGETIAN APPROACH TO TEACHING FORMAL REASONING SKILLS TO COLLEGE PREPARATORY STUDENTS

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The Case theory, a Neo-Piagetian approach to problem-solving, holds that the "executive" schemes used to solve problems should be as efficient as possible. The authors have used a treatment patterned after Case to teach high school students to control variables. The ability to solve proportions was also enhanced. However, certain anomalies in the results when compared with other results have encouraged the authors to replicate the study with 173 college preparatory students in 9th grade physical science and to record qualitative classroom data regarding student-teacher interaction, student responsiveness, student background, etc. In addition, further data have been gathered in the area of retention of formal reasoning skills on last year's data as well as on the study currently in progress. Early scanning of results shows a classic retention curve for controlling variables ability, but an increase in proportional ability in the treatment group. All data have been analyzed using a general linear models program.

The total sample involved in the entire two year study is 325 9th grade college preparatory students at a Northeast Florida private school. Students' formal reasoning abilities have been assessed using the Test of Logical Thinking (TOLT). In addition, the propositional Logic Test (PLT) and Test of Integrated Process Skills (TIPS) have been administered for factor analysis and correlation purposes, respectively. On a combined factor analysis of the TOLT and PLT test, no factor overlap was noted.

The authors' chief goal is to use the Case theory in an instructionally significant manner. Since the nuances of working memory are difficult to assess with paper and pencil tests alone, a qualitative classroom interaction mode will add to our understanding of the educational implications of the Case theory.

These classroom data are especially important when considering the following Case-based problem-solving steps:

> Insure that each student knows why his or her unsuccessful strategy is inadequate and why the appropriate strategy is better, usually by employing questioning probes first followed by explanation and modeling if the probes don't work.
>
> Provide opportunities for practicing the appropriate strategy in a variety of situations.
>
> Introduce new problem features one at a time until students are able to solve complex problems.

Instructional sequences can be designed and revised on the basis of studies which combine the quantitative and qualitative aspects of problem-solving.

ARE PROPORTIONAL AND PROBABILISTIC REASONING NECESSARY PREREQUISITES TO CORRELATIONAL REASONING?

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Purpose/Objectives

The development of various formal reasoning modes has become an area of prime interest for many educators. Knowledge concerning the emergence of these abilities has been shown to be vital to the development of various science curricula and teaching strategies. This paper will focus on one of these modes of formal reasoning, correlational reasoning.

A task analysis suggests a logical hierarchy in which proportional and probabilistic reasoning are prerequisites for correlational reasoning. Correlational reasoning requires a determination of both the proportion of instances in which two attributes appear and the probability of various combinations of attributes occurring. It is the aim of this study to test the proposed logical hierarchy and determine if proportional and probabilistic reasoning are prerequisite to correlational reasoning.

Procedures

Approximately 800 subjects in grades 6-12 were administered the Test of Logical Thinking (TOLT) which includes two items each on probabilistic, proportional and correlational reasoning. Responses from subjects displaying competence in at least one of the three reasoning modes of interest were selected for study (N=579). Response patterns were analyzed to determine if subjects who successfully completed correlational reasoning items also displayed competence in proportional and probabilistic reasoning. For example, a pattern that fits the logical hierarchy is: success on probability, failure on proportions and failure on correlational reasoning. A pattern which disputes the hierarchy is: failure on probability, success on proportions and success on correlational reasoning.

Results and Discussion

Analysis of subject responses reveals that approximately 45% fit the logical hierarchy while 55% of the responses negate the hierarchy. Furthermore 29% of the subjects successfully completed at least one correlational reasoning problem without displaying competence with either proportional or probabilistic reasoning.

These responses suggest that in many cases probabilistic and proportional reasoning are not necessary prerequisites to correlational reasoning. However, it could be argued that the TOLT items allowed success without the full utilization of correlational reasoning, primarily because of the way the problems are posed. In previous studies, it had been noted that subjects of similar age and ability generally scored higher on TOLT correlational items than alternative measures. The impact of very easy correlational items on the proposed logical hierarchy might be significant. To investigate this possibility approximately 200 ninth and tenth grade science students were randomly assigned to three groups and were administered either two Piagetian interview tasks of correlational reasoning (n=40), two correlational reasoning items (n=88) or two alternate items having a question format suggested by other correlational research (n=77). Problem context was identical in all three groups.

Statistical analysis revealed TOLT scores ($\bar{X}$=.51) were significantly higher than either interview scores ($\bar{X}$=.29) or scores on the alternate items ($\bar{X}$=.16). Maximum score for each item type was 2.0. These results may partially account for the success achieved on correlational reasoning items by students lacking proportional and probabilistic reasoning. However, because the absolute magnitude of differences between the three item types is

relatively low, it also seems likely that other explanations including the inadequacy of the hierarchical model, might also account for a large part of these observed discrepancies. Further research into the hierarchical relationship of correlational, probabilistic and proportional reasoning is needed.

SEX AS A FACTOR IN RELATING THE WORDS USED IN DESCRIBING THE ENERGY CRISIS TO THE COGNITION OF FIGURAL PERCEPTION TRANSFORMATIONS

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The purpose of this study was to utilize an information processing approach to determine if sex is a factor in predicting performance on figural transformation tasks from prose descriptions of the participant's perception of the energy crisis. The memory processes which control the figural and verbal cognitive input and output were important considerations.

The participants in this study consisted of one hundred and three seventh grade students ranging in age from 12 to 14 years. This group of students included 53 males and 50 females from a suburban Pittsburgh area school district. They had been identified on the basis of past performance to be average to above average in mental ability.

Four original figural perception transformation tasks were administered to determine performance on figural perception transformation operations.

Prose data was collected by asking each student to write a fifteen minute prose statement based on the question: "What do you think of the energy crisis?"

The prose data was treated with the Snobol 4 computer program and then entered into a multiple linear regression computer program as the independent variables. The perception transformation task scores were entered as the dependent variables. The data were also entered into a stepwise regression and then into an all possible subsets regression and finally back into the multiple linear regression. The intent of this analysis was to utilize the fewest number of independent variables to explain the greatest amount of variance in the dependent variables.

Preliminary findings indicate that males and females do differ in the way they relate to the energy crisis and the cognition of certain figural perception transformations.

Session G-4

A NEEDS ASSESSMENT SURVEY OF HOME ENERGY ANALYSIS TRAINING

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The Center for Energy Studies and the Science Education Center at The University of Texas at Austin have been collaborating to develop and implement educational materials for Home Energy Analysis Training (HEAT). This energy conservation education service first began in anticipation of the 1978 National Energy Act which required all utility companies and energy distribution related businesses to provide to their customers free or for a minimal fee home energy analysis services. The project to date has developed the Home Energy Analysis Training Manual and an instructor's manual for the home energy auditor training workshop. An independent study instructional manual and an audio-visual media package are currently under development to supplement the program.

A needs assessment survey of participating Texas utility companies was performed as one part of the overall project to determine the current status of home energy audit services in Texas and to assess the level of importance and need for the instructional objectives of the HEAT program. The responses to the survey were analyzed by: 1) Describing the importance of the objective, 2) Describing the level of attainment of the objective, 3) Describing the gap between what is important and what is attained, and 4) Factor analysis of the gap between what is important and what is attained. As a result of the analysis of the responses to the survey the following recommendations are made for future HEAT program development:

1. More on-the-job training is indicated to reinforce HEAT instruction.

2. Encourage remaining utility companies to implement home energy analysis services.

3. Additional study is needed to identify the most cost effective modifications for regions within Texas.

4. An information dissemination service to auditors is needed to provide continued education on new developments in energy conservation and home energy auditing procedures.

5. Additional emphasis in HEAT training should be directed toward heat transfer and heat loss/gain concepts.

Session G-4

TEACHER CONCERNS AND THEIR IMPLEMENTATION FOR ENERGY EDUCATION

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Current attention being given energy education suggests consideration of strategies for monitoring its implementation. Difficulties inherent in this sometimes controversial and multidisciplinary area suggest that its infusion into existent curricula may be difficult. The Concerns Based Adoption Model (CBAM) has been developed for understanding and managing the implementation process. One dimension of CBAM is Stages of Concern (SoC). SoC has been used to monitor the concerns of teachers implementing new programs.

Thirty-three teachers were chosen for a two week energy education workshop supported by funds from the Department of Energy. The Stages of Concerns Questionnaire was administered pre and post to the workshop. The results show that awareness, informational and personal concerns were most intense and management, consequence, collaborative and refocusing concerns were least intense. This is consistent with concerns theory. Workshop activities and procedures attended to those initial concerns.

Results of the post assessment showed that the initial concerns had been somewhat resolved and that participant concerns had intensified at consequence, collaboration and refocusing. SoC would appear to be a valuable tool in monitoring the implementation of energy education and in directing the work of those who manage that process.

Session H-2

AN ASSESSMENT OF THE VALIDITY AND PRECISION OF THE INTENSIVE TIME-SERIES DESIGN THROUGH MONITORING LEARNING DIFFERENCES IN GROUPS OF STUDENTS WITH FORMAL AND WITH CONCRETE COGNITIVE TENDENCIES

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Intensive time-series design for classroom investigations has been under development since 1975. Studies have been conducted to determine their feasibility (Mayer and Lewis, 1979), their potential for monitoring knowledge acquisition (Mayer and Kozlow, 1980), and the potential threat to validity of the frequency of testing inherent in the design (Rojas, 1979). This study, an extension of those previous studies, is an attempt to determine the degree of precision the design allows in collecting data on achievement. It also serves as a replicaton of the Mayer and Kozlow study, an attempt to determine design validity for collecting achievement data.

The investigator used her eighth grade earth science students, from a suburban Columbus (Ohio) junior high school. A multiple-group single intervention time-series design (Glass, Willson and Gottman, 1975) was adapted to the collection of daily achievement data on the topic of the intervention, a unit on plate tectonics. Single multiple-choice items were randomly assigned to each of three groups of students, identified on the basis of their ranking on a written test of cognitive level (Lawson, 1978). The top third, or those with formal cognitive tendencies, was compared on the basis of knowledge achievement and on the basis of understanding achievement with the lowest third of the students or those with concrete cognitive tendencies, to determine if the data collected in the design would discriminate between the two groups. Several studies (Goodstein and Howe, 1978; Lawson and Renner, 1975) indicated that students with formal cognitive tendencies should learn a formal concept such as plate tectonics with greater understanding than those students with concrete cognitive tendencies. Analyses used were a comparison of regression lines in each of the three study stages, baseline, intervention and follow-up, t-tests of means of days summed across each stage, and a time-series analysis.

Statistically significant differences were found between the two groups in both slopes of regressions lines (.0001) and in t-tests (.0005) on both knowledge and understanding levels of learning. This confirms the precision of the intensive time series design in that it can distinguish differences in learning between students having formal cognitive tendencies and those having concrete cognitive tendencies.

The time-series analysis found that a model having a trend in the intervention was better than a model with no trend for both groups of students in that it accounted for a greater amount of variance in the data from both knowledge and understanding levels of learning. This finding adds additional confidence in the validity of the design for obtaining achievement data. The analysis models with trend using data from the group with formal cognitive tendencies accounted for a greater degree of variance than the same model applied to the data from the group with concrete cognitive tendencies. This more conservative analysis therefore gave results consistent with those from the more usual linear regressive techniques and t-tests, further adding to the confidence in the precision of the design.

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Session H-2

PROBLEM SOLVING ANALYSIS: A PIAGETIAN STUDY

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Fifty-nine second year medical students were asked to solve twelve Piagetian formal operational tasks. The purpose was to describe the formal logical characteristics of this medical student sample (59 of a total 65 possible) in terms of their abilities to solve problems in four formal logical schemata (i.e., combinatorial logic, probabilistic reasoning, propositional logic, and proportional reasoning). These tasks were presented as videotape demonstrations or in written form, depending on whether or not equipment manipulation was required, and were scored using conventional, pre-specified scoring criteria. The results of this study show that approximately ninety-six percent of the sample function at the transitional (i.e., Piaget's 3A level) stage of formal operations on all tasks and approximately four percent function at the full formal (Piaget's 3B level) stage of formal operations on all tasks. This sample of students demonstrates formal level thinking to a much greater degree than all others reported in the literature to date and these students seem adequately prepared/developed to meet the challenge of their training (i.e., medical problem solving).

Session M-3

RESEARCH INTO PRACTICE: ISSUES IN APPLYING PIAGETIAN-BASED RESEARCH TO TEACHING AND LEARNING SCIENCE A SYMPOSIUM

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Overview

Piagetian theory has guided research in a variety of science education related areas. For example, instruments developed to assess science education programs frequently rely on Piagetian tasks. Innovative educational programs such as the Science Curriculum Improvement Study are based on ideas from Piagetian theory. Teacher training programs frequently present the development of reasoning in a child using the Piagetian model. In these and other ways Piagetian theory has had a profound effect on the practice of science education. In this symposium we identify some of the continuing issues involved in translating Piagetian theory into practice and evaluate the advantages of using Piagetian theory for advancing science education. Examples of different applications of Piagetian theory to teaching and learning science will be given.

Presenters

One presentation will focus on the applications of Piaget's equilibration model to teaching and learning science. The general application of Piaget's theory has centered on understanding the stages of development. For the most part, the process of development as explained by Piaget, has not been given the attention it deserves. The reason for this omission is probably due to the fact that Piaget's equilibration model is difficult to understand. Nonetheless, it is essential that any application of Piaget's theory underscore the need to 1) understand the process of equilibration and 2) translate the understanding into teaching strategies that enhance the possibility of learning and development. While difficult to understand, Piaget's model of equilibration does provide a "learning model" within the developmental theory.

In the second presentation, the director of a teacher training program will present examples of how Piagetian theory has influenced teacher preparation. Both the procedures used to teach pre-service elementary school teachers and the content of their programs reflect an influence of Piagetian theory. Based on Piaget's emphasis on concrete experience, teacher training includes a great deal of concrete experience with children and concrete examples of how they reason. In addition, teachers receive experience in diagnosing students' reasoning strategies by comparing student response in interview situations to expectations based on Piagetian theory. Piagetian research helps teachers recognize alternative conceptualizations of scientific phenomena that students might hold and assists teachers in designing educational programs to remediate the alternative conceptualizations.

The application of any theoretical model to practical problems raises methodological issues. A methodologist and a science education researcher will discuss the ramifications of applying Piagetian theory to educational practice. For example, what has been called in Piagetian theory, horizontal decalage or variability in performance among individuals thought to be at a particular Piagetian stage is difficult to incorporate into a method for

diagnosing strategies used by learners. In addition, the content or context of a particular reasoning problem often influences performance but is not a part of the theory developed by Piaget. Finally, issues in the reliability and validity of measurement of reasoning strategies often make it difficult to translate theoretical views of Piagetian theory into educational practice.

Each presenter will consider the difficulties of applying a theory that primarily focuses on development to science education practice which primarily focuses on learning. Whereas Piagetian theory may be more suited to assessment of developmental level than to design of instructional programs, it has been used in both domains. Piagetian theory has had a profound effect on science education practice. This effect deserves continued examination.

Each of these presenters will focus, then, on a different aspect of the application of Piagetian theory to science education practice. The first presenter will focus on application of the equilibration model to teaching and learning science. The second will focus on teacher preparation. The third will focus on methodological issues transferring research into practice. The fourth will serve as a discussant to broaden the perspective of the presentation by considering the implications for graduate student training in education.

Session H-4

BRIDGE BETWEEN NEURO-COGNITIVE RESEARCH AND SCIENCE EDUCATION

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Historically there has been interest in the connection between the human brain and learning or teaching. Early research on learning depicted the brain as a black box while teaching and learning were simulated by electric shocks, food pellets and so forth. The science fiction and horror films watched by children vaguely allude to the connection between altering the brain and subsequent bizarre behavior. Today the computer industry bears further testimony to assumptions about the connection between the human brain and learning or the storage of information.

Yet in spite of our intuitive acceptance of the relationship between the human brain and learning, there has been little direct contact or collaboration among researchers from the fields of neuroscience, cognitive science, and education. In fact, until quite recently neuroscientists, cognitive scientists and educators rarely sat down at the same table to talk about areas of common interest. However, the past decade - the 1970's - has witnessed a change; and some are suggesting that a new field of science is about to emerge.

In 1975, a group of scientists met at Asilomar, California, expressly to discuss the relationship of recent research in neurophysiology and brain biochemistry to learning. The results of their meeting appeared in a report, "Neural Mechanisms of Learning and Memory."

Then early in January, 1981, a symposium entitled, "The Brain Sciences and Education" was presented at the American Association for the Advancement of Science annual meeting in Washington, D.C. Neuroscientists, cognitive psychologists and educators were brought together to describe the most important advances and research questions in their fields, and to explore possible areas of overlap and mutual interest.

Most recently (March, 1981) the National Science Foundation, the National Institute of Education and the Sloan Foundation jointly sponsored a meeting in Washington, D.C. in order to bring together 30 outstanding neuroscientists, cognitive scientists and educators. The conference was designed to enable participants to share information about research in their three areas to see the implications of their work for the other fields represented and to explore promising research questions for the future.

What is the significance of these activities for those concerned about research in science education? The purpose of this paper is to describe the highlights of the papers presented at these three meetings, to summarize the discussions that followed, and to explore the implications for persons whose research interests are in science education. The following questions will be addressed:

- What theoretical models and conceptual frameworks are dominant in neuroscience, cognitive science, and education today?
- What are the most promising methods and techniques used in each of these fields?
- What recent findings from neuroscience and cognitive science have greatest relevance for research in science education?
- What or where are the gaps in knowledge among these three fields?

IDENTIFYING MEDIATING FACTORS OF MORAL REASONING IN SCIENCE EDUCATION

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Piaget (1972) and Iozzi (1976) have suggested that individuals tend to reason at more sophisticated levels in areas in which they have more knowledge, interest and experience. The central purpose of this study was to investigate to what extent and how such factors as knowledge of content, attitudes, value commitment and past experiences mediate the formation of moral judgments on science oriented moral dilemmas. Specifically, the three main objectives were: 1) to determine if environmental science majors exhibit higher levels of moral reasoning on non-technical environmental social issues than on general social issues; 2) to examine the extent to which possible mediating factors (environmental attitudes, knowledge, and personal experience) account for the differences in moral reasoning; and 3) to examine how, in addition to what extent, such factors are revealed as people form moral judgments.

Subjects were obtained from two distinct groups: 1) Environmental Science majors from SUNY at Syracuse, School of Forestry (86 subjects); and 2) non-science majors from Syracuse University (105 subjects).

Phase One of the study involved a multiple posttest only design with predicted higher order interactions. Two major types of analyses were performed: 1) a 2 x 2 repeated measures ANOVA, which examined group (environmental science vs. non-science) differences in moral reasoning applied to different contexts (social and environmental); and 2) stepwise and hierarchical multiple regression to determine to what extent mediating factors account for differences in moral reasoning applied to environmental issues (D.V. = moral reasoning on environmental issues, I.V.'s moral reasoning on general social issues, ecology comprehension, environmental attitude, verbal commitment, actual commitment, affect and group membership).

Phase Two of the study employed a unique qualitative design. Ten pairs of subjects were matched on the basis of standardized factor scores (obtained from the data of Phase One) and selected to participate in a tape-recorded interview. This phase examined how subjects' knowledge, attitudes, value commitments and past experiences were expressed and used as they discussed ecology-oriented moral dilemmas and attempted to resolve them.

The results for Phase One showed a significant interaction effect (group by moral reasoning context, $p \leq .05$) and a significant main effect for moral reasoning context ($p. \leq .001$). Significant differences in moral reasoning ($p \leq .05$) existed between environmental science majors and non-science majors on environmental dilemmas, but not on general social dilemmas. The results also show that moral reasoning ability on general social issues uniquely accounts for 30.7% of the variance of environmental moral reasoning ($p .001$), while affect, group membership, environmental attitude and ecology comprehension uniquely account for 3.1%, 2.1%, 1.0% and .09% of the unexplained variance ($p \leq .001$) respectively.

The results of Phase Two identified four trends which revealed how subjects construed the environmental moral dilemmas. Those trends were labeled as follows: 1) Causistical Reasoning: Fact vs. the Hypothetical; 2) Stage Response Differentiation; 3) Resolving Means and Ends; and 4) Normative Reasoning: The Influence of Personal Experience.

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Session H-4

AN ADULT MARINE INVENTORY II: SUBSAMPLE DIFFERENCES

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Need For The Study:

This report is a continuation of a study reported at the 1981 NARST meeting in which the development and validation of an inventory of adult marine knowledge were described. The present study was conducted to determine if there were differences in such descriptor variables as sex, place of residence, educational level, occupation and marine studies course background. These two studies were conducted in preparation for an adult marine education and information project sponsored by National Sea Grant.

Procedure

The "Northern New England Marine Inventory" was administered to a final sample of 479 adults in eighteen test centers selected from coastal and inland Maine. Potential significant differences were sought using one way analysis of variance along with the Scheffé procedure and t-tests on total scores. Factor analysis and multiple linear regression were used to investigate score trends. Reliability using KR20 and split half methods were recalculated for the complete sample.

Results

Split half reliability of 0.882 and KR20 of 0.883 improved with the full sample as compared to the previously reported pilot study. Significant differences by descriptor variables were found when the sample was divided into groups by sex, age, level of education, occupation, number of marine courses taken, and distance of residence from the coast.

Sample members who were teachers out scored non-teachers, with science teachers significantly out scoring other teacher groups. Multiple regression showed that thirty percent of the variance was accounted for by education and distance of residence from the coast. Other variables accounted for less than ten percent of the variance. Factor analysis revealed little item clustering of any real importance.

Session H-5

NONPARAMETRIC RESEARCH

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Session I-1

LOGICAL ABILITY AND ACHIEVEMENT IN COLLEGE LEVEL PHYSICS

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Two tests of logical ability were administered to 155 undergraduate students taking college level physics to determine the relationship between logical ability and achievement in such courses. The first test (P.L.T.) is representative of a conditional evaluation task in which the truth of a proposition is determined by the truth of its component parts. A second test (P.C.) is representative of a conditional syllogism task in which the conclusion necessarily follows from the truth of the premises. These two forms of the conditional have produced differing results and interpretations as to the meaning of conditionals. Results from these tests were then analyzed and related to the final examination results.

Most subjects were able to answer correctly both material biconditional (M.B.) and material implication (M.I) items on the P.L.T. In general these subjects were able to interpret the M.B. and M.I. conditionals by correctly processing instances referred to them. Considerable variation was, however, found in the conditional syllogism in both form and type. Modus ponens (M.P.) items were correctly answered by almost all subjects. The affirmation of the consequent (A.C.) items proved to be somewhat more difficult than M.P. Within the A.C. items the M.I. were more difficult than M.B. The denying the antecedent (D.A.) and modus tollens (M.T.) appeared about equally difficult and were both more difficult than A.C. and M.P.

Responses to the conditional syllogisms appear to be related to the associative and logical properties of its elements. When the attributes in the minor premise and conclusion correspond to those in the conditional, subjects encounter almost no difficulties. When the sequence of attributes appearing in the minor premise and conclusion is the reverse of their appearance in the conditional, some difficulties occur. If the attribute in the minor premise is the complement of one appearing in the conditional, the error rate increases substantially. Finally when attributes in both the minor premise and conclusion are the complements of those appearing in the conditional, approximately 50 percent of the subjects respond incorrectly. The degree of inference required by the task appears related to subject difficulties.

A factor analysis generated four clearly identifiable factors representing different cognitive abilities and levels of difficulty. These factors were marginally related to results on the final examination. The factor most related ($r=0.3$) was one requiring a subject to generate a subset of possible instances from a single attribute. The simplest factor requiring matching ability did not correlate with achievement since students correctly answered these items. Factors requiring higher degrees of inferencing ability appeared only weakly related to achievement.

A number of questions can be raised about student abilities engaged in introductory courses as well as evaluation procedures. Examinations are frequently multiple choice items which may fail to adequately reflect what is taught as well as what is learned. Greater effort is needed to understand the cognitive abilities of students and how they are engaged and influenced in such courses.

Session I-1

LOGICAL ABILITY AND ACHIEVEMENT IN HIGH SCHOOL LEVEL PHYSICS

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Two tests of logical ability were given to 72 high school students enrolled in a PSSC physics curriculum. The results of these tests were compared with two measures of achievement.

The tests of logical ability were used to evaluate two forms of conditionals. The first test (P.L.T.) evaluates the truth of a proposition by the truth of its component parts. The second test (P.C.) employs the conditional syllogism consisting of a conditional statement followed by a minor premise and conclusion. These lead to the four types of syllogistic responses for the two forms of conditionals.

Most students responded correctly to the material biconditional (M.B.) and the material implication (M.I.) on the P.L.T. The syllogistic form yields considerable variation on both form and type.

The two measures of physics achievement are PSSC unit tests on mechanics (PSSC) and the Dunning-Abeles Physics Test (D.A.). The two tests are quite different in terms of the types of question asked and the reasoning apparently needed for correct responses.

A regression analysis of the data indicates the M.I. types on the P.C., affirming the consequent (A.C.) and denying the antecedent (D.A.), form a significant cognitive factor. This factor is found to correlate $r=.35$ with the PSSC test and $r=.32$ with the D.A. test. The PSSC and D.A. tests correlated with each other with $r=.70$.

The percent of correct responses on the P.C. forms and types were compared for the high school and university sample. This high school sample exhibited greater accuracy on A.C. and D.A. types than did their university physics counterparts. They were very nearly equivalent on modus tollens (M.T.) responses and slightly better on modus ponens (M.P.) types.

These data raise the question as to how recognition of the A.C. and D.A. types is related to problem solving strategies on achievement tests. Individual test items need to be grouped and these groups or clusters compared with individual response types on both the M.B. and M.I. forms of the P.C. test.

Greater effort is needed to understand how various types of achievement questions engage or require the various forms and types of conditionals.

TWO YEAR COMMUNITY COLLEGE STUDENTS AND SYLLOGISTIC REASONING SKILLS

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Sixty-five students taking a course in general physics at a two year rural community college in an industrialized eastern state were administered tasks at the beginning of the semester which involved the evaluation of instances in relation to a conditional statement, and analysis of logical syllogisms. The students were from two kinds of programs: career (technically) oriented and transfer (science) oriented. One fourth of the students were female.

The performance of the students on both tasks was weaker than among students taking similar courses at high school and university level. However, the pattern of responses, the rank ordering of item difficulty and the factor structure of the tests were consistent across the three groups.

The performance was also related to achievement in the physics course. The moderate correlation of these skills to achievement in science suggests that more studies must examine the facets of logic required in our science courses. In addition, it appears that a re-examination of our testing and evaluation procedures relative to our objectives in the courses we teach may be necessary. Further, if the ability to understand and follow rule statements is important at the university level as found in other studies, and two year students are weak in this regard, then our definition of "basic" skills, at least for science students, may have to be modified.

Session I-2

LOGICAL REASONING ABILITY OF PRE-NURSING AND NURSING STUDENTS AT AN URBAN COMMUNITY COLLEGE

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The intent of this ex post facto investigation is to determine the logical reasoning ability of pre-nursing and nursing students enrolled at an urban community college. In order to do this two groups were given a number of tests designed to discover different aspects of logical reasoning ability such as rule learning, concept identification, ability to utilize disconfirming strategy and combinatorial reasoning ability. Various forms of the tests were used and refined in this preliminary study. It was determined that nursing students exhibit greater ability to perform some logical reasoning tests than pre-nursing students. Disjunctive logical operators in some logical forms were found to be better understood by nursing students than pre-nursing students. It may be that some of the difficulty encountered by these community college students is the result of experiential deprivations early in life. Design of new curricula should take into account deficiencies in logical reasoning.

REASONING SKILLS AND SCIENCE COURSE ACHIEVEMENT

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A study was conducted using a sample of 47 suburban community college students in an introductory level chemistry course during the 1980-81 academic year. The purpose of the study was to determine if a relationship existed between course achievement and skills exhibited by students on various measures of deductive and inductive reasoning. A secondary purpose of the study was to examine the interrelationships between the various reasoning tasks.

The results of the study indicate that course achievement was significantly correlated with the measures of deductive reasoning and cognitive style, but not with the inductive reasoning tasks. The tasks of deductive reasoning, mathematics skills and propositional logic were significantly intercorrelated, indicating that they have a common component, probably a deductive reasoning skill. The Group Embedded Figures Test was correlated significantly with course achievement and inductive reasoning, but the latter two were not correlated with each other. It is speculated that it was probably a cognitive style component of the Group Embedded Figures Test which was related to course achievement.

Session I-2

A STUDY OF REASONING SKILLS IN INTRODUCTORY COLLEGE SCIENCE COURSES

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This is a report of a pilot study of selected reasoning skills identified as important in the study of science. The intent was to explore different diagnostic instruments which could also be used in subsequent studies to indicate progress in overcoming these deficiencies. The questions considered in this pilot study are: 1. To what extent and in what ways do university faculty perceive evidence of problems with science reasoning skills among students in introductory courses? 2. Can we construct a meaningful operational definition of Reasoning Skills important in science separate from the general intelligence (IQ) factor? 3. Can we demonstrate a range of science reasoning scores in selected science skill areas (for students enrolled in introductory science courses) which show positive correlation with overall performance in the course as indicated by earned grade?

The population selected for study consisted of students enrolled in lower level introductory science courses on the University of Wisconsin campuses at Green Bay, Milwaukee, and Superior and at Marquette University, Milwaukee.

Cognitive tests were taken from the ETS Kit of Factor Referenced Tests (Harmon, 1975). This is a well researched battery of tests that appears to cover the essential cognitive abilities related to science reasoning skills. With the help of an advisory committee, eight factors were chosen for careful examination. These are: Verbal Closure, CV; Verbal Comprehension, V; Reasoning General, RG; Reasoning Logical, RL; Spatial Orientation, SO; Spatial Scanning, SS; Visualization, VZ; and Integrative Processes, IP. In addition to the ETS Factor tests, the TOLT test (Test of Logical Thinking) was included in the battery of tests as another measure of quantitative skills: controlling variables, proportional reasoning, probabilistic reasoning, combinatorial reasoning and correlational reasoning.

Significant differences in science reasoning skills were reported by a majority of the faculty. At least half of the students had significant problems and in at least one of the classess, 70 to 80 percent of the students had problems with science reasoning skills.

Completed tests booklets were obtained from 254 students, at four institutions. Multiple regression analysis shows that the vocabulary test, used here as an indication of general intelligence, accounts for most of the variance in final grades. Two conclusions can be drawn from this. First, the data collected in this pilot study do not support a definition of "reasoning skills important to science" independent of general intelligence. Second, it may well be that the introductory science courses have become sufficiently descriptive and verbal rather than quantitative so that the quantitative/spatial/multiple variable skills examined in this study play only a secondary role in achievement as indicated by earned grade.

Major differences, on most cognitive factors many of which were statistically significant, were found between science majors and non-science majors, between males and females and between those students classified formal and concrete operational by means of scores on the TOLT test.

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Session I-4

THE EFFECTIVENESS OF PERTINENT BIOLOGICAL SCIENCE-CONTENT ARTICLES AND THE RELATING OF BIOLOGICAL SCIENCE CONTENT TO THE NON-SCIENCE STUDENT'S MAJOR ON ATTITUDE MODIFICATION AND ACADEMIC ACHIEVEMENT

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The objective of this study was two-fold. The first objective was to investigate the effectiveness of emphasizing pertinent biological science articles and articles' source on positive attitude development toward science, scientists and scientific careers and on biological science content achievement for the nonscience major student. The second objective was to investigate the personal relating of biological science content in written form to the nonscience student's major on positive attitude development toward science, scientists, and scientific careers and on biological science content achievement.

A population of 60 undergraduate subjects consisting of 56 freshman and 4 sophomores participated in the study. Each subject was administered the investigator-constructed biological science final examination instrument, the Allison instrument, and the investigator-constructed instrument of perceived relevance of biological science content to the subject's major. The instruments assessed prior and post study biological science content achievement, attitude toward science, scientists, and scientific careers and the relevance of biological science content to the subject's major, respectively. Each subject was randomly assigned to one of four treatment groups for a duration of 10 weeks in the required biological science course for nonscience major students.

An analysis of covariance using pretest scores as the covariate and a correlational analysis were used for data analysis. Significant difference was observed at the .05 level between the two levels of emphasizing/not emphasizing biological science content articles and articles' source relative to course content on attitude and on academic achievement in biological science content as measured by the Allison instrument and the investigator-constructed biological science final examination, respectively.

There also was a significant difference at the .01 level for prior to the study versus post-study perceived relevance of biological science content to the nonscience student's major in favor of treatment level B_1 (pertinent biological science-content articles and articles' source emphasized).

There were no significant correlations between beginning of the course attitude toward science, scientists, and scientific careers and beginning of the course biological science content achievement scores for each of the subjects in the four treatment groups as measured by the Allison instrument and the investigator-constructed biological science final examinaton, respectively.

There was a significant correlation between post-attitude toward science, scientists, and scientific careers and post-academic achievement in biological science content as measured by the Allison instrument and the investigator-constructed final examination, respectively. This finding was in favor of the treatment group having personally related biological science content to the student's major and experienced the emphasizing of pertinent biological science-content articles and articles' source.

There were no significant interactions between personally relating/not relating biological science knowledge to the non-science student's major and emphasizing pertinent biological science-content articles and articles' source relative to course content as measured by the investigator-constructed and the Allison post criterion instruments, respectively, on neither attitude toward science, scientists, and scientific careers nor for academic achievement in biological science.

The results obtained in this study indicated that emphasizing the content in pertinent biological science-content articles and articles' source had a significant effect on positive attitude development toward science, scientists, and scientific careers and on academic achievement in biological science content. Finally, there was a significant correlation between post-attitude toward science, scientists, and scientific careers and on biological science content achievement as measured by the Allison instrument and the investigator-constructed biological science final examination.

Session I-4

NSF CURRICULUM PROJECTS AS SCIENCE COURSES FOR ELEMENTARY EDUCATION MAJORS

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This study compares the use of ESS and IPS as vehicles for science courses for pre-service elementary education students. Student scores on the Test of Understanding Science (TOUS); Cognitive development; Tuckman semantic differential; Laboratory Program Variables Inventory and a questionnaire based on the Science Curriculum Assessment System of Interaction Analysis are reported.

GENERAL SESSION III

WHAT EDUCATION RESEARCH SAYS TO THE SCIENCE EDUCATION RESEARCHER

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Session J-1

THE DEVELOPMENT, IMPLEMENTATION AND GENERAL RESULTS OF THE MANITOBA SCIENCE ASSESSMENT PROGRAM

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OVERVIEW

The Manitoba Science Assessment Program was a large scale system for assessing the ability of science students as well as for obtaining current information regarding the facilities, the curriculum and the instructors. Information concerning the development, implementation and general results of the 1980-81 assessment is presented. Emphasis is placed upon the unique aspects of the program which were developed to handle the problems of involving a variety of interested personnel, obtaining valid instruments and acquiring a base line for handling the results.

The Manitoba Science Assessment Program was structured to measure a broad spectrum of student ability. The purposes of the assessment as stated in the 1981 report are:

1. To provide benchmark indicators about the level of student achievement in the Province of Manitoba.

2. To obtain data on student achievement that will assist in curriculum and program improvement, both at the provincial and local level.

3. To assist school divisions in both student and system evaluation.

4. To help teachers improve their student evaluation skills.

The goal areas selected for the science assessment were:

1. Knowledge and comprehension of important generalizations, facts, terms, principles and concepts of science.

2. Application of scientific knowledge and principles to new situations as well as to practical problems.

3. Higher cognitive level thinking, including the ability to analyze and evaluate science data.

4. The processes of science, both basic and integrated.

5. The nature of science.

6. Knowledge of safety procedures and precautions in the use of materials and equipment.

7. Interest in and attitudes toward science.

The assessment instrument, developed by a contract team, was administered to an estimated 36,600 students in Manitoba schools, in grades five, eight and eleven. The results of a ten percent sample were analyzed and published in a Department of Education Publication entitled Preliminary Report: Test Data.

Interpretations of the results were then made by teachers, other educators, and trustees. A second publication entitled Final Report, which contains the results and interpretations based upon these results, was released in June, 1981.

A teacher questionnaire was administered concurrently with the assessment instrument to all grades five, eight and eleven science teachers in the Province.

The results of this questionnaire were used to structure a normative profile of the science teacher at each respective grade level. The profile and other relevant data from the questionnaire are included in the Final Report.

Paper #1

ALTERNATIVE METHODS FOR INTERPRETING SCIENCE ASSESSMENT DATA

The purpose of the study was to investigate the suitability of each of several approaches to the interpretation of results of data from student testing in broadly-based studies of student achievement such as the Manitoba Science Assessment Program (1980). Both norm-referenced comparisons including progress assessment, and various judgements about province-wide or state-wide performance made by panels of teachers and others have a role to play in student assessment studies. Approaches to interpretation of such results need to be clarified in the context of testing theory. They also need to demonstrate their utility through application in an actual assessment setting.

Methodologies for establishing ratings for student performance data using estimates of minimal acceptable and desired performance were presented. The contribution which can be made to rating panels by non-teaching experts and both pre- and in-service teachers as well as members of the public was presented and discussed. Individual and group consensus approaches to making estimates were also compared and discussed.

Observations, methods, and data especially from Manitoba (1980), but also from Alberta (1979) and British Columbia (1978) science assessment or achievement programs and the National Assessment of Educational Progress (1967-77) were used as data sources to illustrate points relative to the discussion. Specifically, prospects for meaningful inter-provincial and international comparisons of student scores were made. Emphasis was placed on interpretation for the purpose of progress testing as well as for determining the status of science education in Manitoba.

The conclusions indicated that both norm-referenced comparisons of achievement and various other standards centering around teacher ratings of appropriate performance were theoretically defensible. They also indicated that when applied in the ways described they could make a useful contribution to assessment interpretation efforts such as the Manitoba Science Assessment Program (1980) and other similar studies.

Paper #2

DISPARITIES BETWEEN SCIENCE CURRICULUM THEORY AND TEACHER PRIORITY AND PRACTICE AS REVEALED BY A TEACHER-DESIGNED SCIENCE ASSESSMENT

The unique feature of the Manitoba Science Assessment (MSA) was the role that science teachers played in the assessment process. The contract team served as a facilitator by formulating an exhaustive list of science objectives which were screened by teachers and subsequently used by the contract team in drafting a large number of test items. Teachers then selected the items to be included in the assessment instruments. Upon completion of testing, teachers judged the percentages of pupils responding correctly to each item and to subsets of items reflecting the various subtests as "strength," "very satisfactory," "satisfactory," "marginally satisfactory" and "weak".

This approach to assessment differed from other educational assessments described in the literature such as the National Assessment of Educational Progress, the British Columbia Assessment and the Alberta Science Achievement Study in that teachers were not heavily involved in the test design.

The assessment results revealed as much about science teachers as about science students. Teachers were unable to select accurately test items that a majority of their students could answer correctly. Performance was judged very satisfactory to marginally satisfactory on 59 items missed by 50% or more students and no item missed by more than 47% of the students was judged weak.

In response to an opinionaire, teachers at all three levels, ranked history and philosophy of science lowest in terms of importance in teacher education, psychology of learning third lowest, just after special education, and science

as a way of thinking at the median or below on a list of 16 items. However, all the objectives drafted by the contract team in the area of nature of science were ranked high for inclusion in the assessment.

Teaching techniques, science content and laboratory safety in pre- and in-service training, were rated high. Teacher reports on a survey of classroom activities indicated a strong emphasis on teacher direction and control as opposed to opportunity for student-directed inquiry activity.

The implications of these results are that a wide discrepancy exists between theory as expounded by the science education "establishment" and practice and priority as expressed by teachers. Teachers seem to be content-oriented, unaware of the intellectual abilities of their pupils and disinterested in professional preparation that might change their orientation or increase their understanding of the the learner. On the other hand, those who talk and write about science education and teach science teachers how to teach science, advocate understanding of the process of learning, the nature of science and student inquiry.

If science educators are to bridge the gap between theory and practice, they must develop programs of science teacher education that encourage and enable beginning teachers to implement their (the science educators') theories.

Paper #3

THE RELATIONSHIPS BETWEEN STUDENT ACHIEVEMENT IN THE MANITOBA SCIENCE ASSESSMENT PROGRAM AND TWO VARIABLES: TEACHER RATINGS OF IMPORTANCE OF OBJECTIVES AND TEACHER JUDGEMENTS OF STUDENT SUCCESS

This study consists of investigating two aspects of the results of a province-wide testing program in science. The science tests which were given to pupils in grades 5, 8 and 11 were designed to assess knowledge, understanding and skills to provide an indication of student performance for curricular areas in science as well as information on other goals such as processes of science, safety procedures and the nature of science.

The relationship between student achievement and teacher ratings of the importance of the objectives on which the items were based showed a parallel or one-to-one relationship. The areas of processes of science/safety/nature of science were selected as most importance, and the student scores on these areas were highest. Success in other areas (life science, earth and space science, and lowest physical science) paralleled the importance given to the objectives in these areas. The only exceptions were the grade 11 results where earth science results were lowest rather than physical science.

The relationship between student achievement and teacher judgements of student success shows a somewhat similar trend. Teachers expect high performance on the processes of science/safety/nature areas, and were generally dissatisfied with the pupil scores. Teachers rated the content areas as basically satisfactory. Life science was rated best for grades 5 and 8, but no clear distinction shows up for the grade 11 results.

Many questions are suggested by these apparent relationships. Does the importance expressed by teachers for the different areas influence the pupil success? Also, if teachers value the processes of science/safety/nature of science areas so highly, why are they not reflected in their instructional practices as indicated in the accompanying teacher survey? These questions urgently need satisfactory responses.

Paper #4

PROCESSES OF SCIENCE AND NATURE OF SCIENCE COMPARISONS AND ANALYSES FOR THE MANITOBA SCIENCE ASSESSMENT PROGRAM FOR GRADES FIVE, EIGHT AND ELEVEN

The purpose of this study was to compare and analyze the Processes of Science and the Nature of Science data derived from the Manitoba Science Assessment Program (1980) for grades five, eight and eleven. The findings related to the two topics are presented and discussed in relation to (a) the prioritizing and pre-assessment of objectives used for item selection; (b) teacher committee estimations and expectations of student performance on test items; (c) demographic information pertaining to classroom teachers of the tested students, particularly for teaching and classroom operations. The performance of females versus males and limited cross-grade comparisons are presented in terms of the science processes and the nature of science items.

Several important findings were noted. The scores of both males and females were quite similar for both the processes of science and the nature of science items. The proportions of test items allotted to processes and to nature of science, as compared to content-type items, reflected a high stress on content goals, but did not reflect the high teacher ratings of the importance of the corresponding processes objectives. Measuring, as a process, showed improvement as grades progressed upwards. Close scrutiny given to classroom teaching data and to corresponding evaluative comments did not reveal a concern for the teaching of the science processes. While student-centered science is readily revealed at the grade five level, grade eleven teacher data show a much more directed and controlled and a less personal approach. "Graphing of experimental data" was 'hardly ever' to 'occasionally' done at any of the three grade levels, while "listening to lectures" was one of the highest frequency activities listed.

"Science as a way of thinking" was not considered as being important as an inservice topic. While teachers expressed the need for help in designing experiments and for activity-based science, they did not seem to recognize the role that processes of science could play in supporting that type of endeavor.

Among recommendations derived from teacher committees there were several of concern. There is a need for the processes of science to enhance classroom activities, with recognition to be given to the explicit practice of experimenting, hypothesizing, and the controlling of variables. There is a need for the teaching of the more quantitative type of measurement. The nature of science must be related more deliberately to everyday activities; and there is a need to develop supplementary resources for teachers in the processes of science and the nature of science areas.

Session J-2

EFFECT OF FORMAT AND INTERVIEWER ON PERFORMANCE IN PIAGETIAN TASKS

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Originally, Piagetian tasks were administered by the clinical method, for the purpose of gaining insight into an individual's pattern of thinking. More recently, the tasks have been used to diagnose the level of cognitive development reached by an individual, implying an acceptance of the structures proposed by Piaget. Recent applications of this diagnostic technique have used large samples, for which the traditional clinical method is too inefficient, and have led to the development of pencil and paper tests given to class-size groups. Despite the increasingly widespread use of group tests, few studies have undertaken to determine whether student performance differs under conditions of group or individual testing. Most of the comparative studies have been correlational; none have shown how the average levels of performance on a range of tasks differ between the two formats.

In preparation for a national survey of the cognitive development of Ghanaian secondary school students, this author developed a number of Piagetian tasks in a format suitable for administration to about eight students at a time. This format seems to offer an attractive compromise between the efficiency of the group method and the interaction and fexibility of the clinical method. These last features are particularly important in a situation where the subjects are confronted with an unfamiliar type of test and a language which is not their mother tongue. In order to validate the test for use on a large sample, it seemed necessary to investigate the effect on students' performances of using different forms of the same tasks, and the use of different interviewers, especially those from a culture different from that of the students. For this purpose, a sample of 192 students was drawn at random from classes 1 and 3 from four different secondary schools and given the battery of tasks, either in the individual or small-group format, by one of four different interviews (two Ghanaian men, a Malaysian woman, and an American man). Results of a three-way analysis of variance with level in school, form of test, and interviewer as fixed effects, showed that for four out of eight tasks, there was not significant difference in the effect of either form of task or interviewer on performance ($p \leq 0.25$, power 0.99 for a hypothesized difference in means of 0.25 of a full developmental level). The four tasks which met these criteria were Horizontality of Water Level (from The Child's Conception of Space), Curves of Movement (from The Child's Conception of Geometry) Combination of Colorless Chemicals (from The Growth of Logical Thinking), and Quantification of Probability (from The Child's Conception of Chance). The last three of these tasks each cover a wide range of intellectual levels, from pre-concrete to full realization of formal operational thinking. Low correlations are found among all these tasks, casting doubt on the existence of a unified structure for formal operational thought, at least in the sample used in this study.

Session J-2

AN INVESTIGATION OF THE USE OF THE SHIPLEY TEST AND THE PIAGETIAN TYPE BATTERY FOR DIFFERENTIATING STUDENTS OF SAME GRADE LEVEL FROM TWO DIFFERENT JUNIOR HIGH SCHOOLS

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The purpose of this study was to compare the effectiveness of the Piagetian type battery (Moser, 1977) and of the Shipley test on abstract reasoning (1940) in detecting differences in mental ability for students of the same grade level from two different junior high schools. Mental ability in relation to certain characteristics of adolescents was also investigated. Students' characteristics were categorized for their home environment and their degree of openmindedness. The home environment variables were sibling rank and the education of their parents. Their degree of openmindedness was measured with the Form E of Rokeach's dogmatism scale (1960). Their verbal and figural mental ability were measured with the Shipley test on abstract reasoning (1940) and the Piagetian type battery, respectively. Piagetian operations were seriation, correspondence, reversibility, transitivity, class inclusion, transformation, logical add-subtract, horizontal classification, and multiple classification.

One hundred and eighty eight students, enrolled at the same grade levels, were from two suburban school districts in the Pittsburgh area, Southwestern Pennsylvania. Ninety one subjects were from school A (39 girls and 52 boys), and ninety seven subjects from school B (48 girls and 49 boys). Their average age was 13.5 years.

The Pearson's Chi-square Test of Association (Hayes, 1966) was used to test the hypotheses of no statistical association between schools and home environment variables. The investigation for significant differences in mental ability between one school and the other, and in degree of openmindedness between one school and the other, was conducted using the BMDP7D program (Dixon, 1979).

Results demonstrate that subjects from the two junior high schools differ in a) 44.44 percent of the mental ability traits measured by the Piagetian type battery, b) 5.0 percent of the aspects of the belief-disbelief system measured by the Form E of Rokeach's dogmatism scale, c) the number of older siblings, and d) the education levels of their parents.

The Shipley test was found ineffective in detecting the differences in students' mental ability. This could be attributable to the fact that the Shipley test on abstract reasoning is built upon problems related to the order of the letters in the alphabet, the sequence of the natural numbers, and the position of the cardinal points. In our culture children grow up with these problems.

For these particular samples it may be concluded that adolescents with the larger number of older siblings, and adolescents whose parents have a higher level of education, perform better on the Piagetian type battery tasks. It may also be concluded that students who agree strongly with item number 10 of the Form E of Rokeach's dogmatism scale ("There is so much to be done and so little time to do it in.") perform better on the tasks of the Piagetian type battery. This item is intended to measure students' beliefs regarding the uncertainty of the future.

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Session J-2

INSTRUMENT DEVELOPMENT TOWARDS THE ASSESSMENT OF GENERIC PROBLEM SOLVING ABILITY IN MEDICAL STUDENTS

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The purpose of this investigation was to develop a set of problem solving cases which could be used to assess the problem solving ability of pre-clinical medical students. As a result of the instrument development pilot study, eight problem solving cases were developed for use with a sample of sixty-seven University of South Dakota freshman medical students during the spring of 1980. These problem cases were administered during a two hour class session and the subjects were asked to attempt solution to all of the problems during the time allotted. The problem cases were scored by the investigators, using pre-specified scoring criteria, and it was determined that the majority of subjects (57 to 91%, depending on the problem case) operated at the Piagetian 'formal' level, the Gagné 'higher order rule invention' level or at Bloom's 'evaluation' level. Each of these operational levels are the highest levels of thinking and are generally referred to as problem solving.

An attempt was made to identify significant relationships between these eight problem solving cases and the subject's various grade point averages and Medical College Admissions Test scores (MCAT). Few strong relationships were found and it was concluded that the eight problem cases taken together assessed a level of problem solving not assessed by the MCATs or the various GPAs. This problem solving level is the formal level and requires the subject to arrive at interim solutions (higher order rule invention), then using them to combine with other data in the problem to, ultimately, arrive at the final solution. In Bloom's terminology, this is a combination of analytic, synthesis and evaluative thinking.

Session J-4

EFFECTS OF ENGAGEMENT QUALITY ON INTEGRATED PROCESS SKILL ACHIEVEMENT IN GRADE 7-8 SCIENCE STUDENTS OF VARYING ABILITY LEVELS

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Introduction

Time on-task has been identified as a process variable that accounts for much of the variation in achievement. Most studies of student engagement have used a dichotomous system in which a student may be coded as being on-task or off-task. This study, however, goes beyond this dichotomy in attempting to determine the effects of engagement quality on achievement.

Purpose

The objective of the study was to determine the effects of enhanced levels of generalizing and planning engagement on integrated process skill achievement in grade 7-8 science students of varying formal reasoning ability. Specifically, this study addresses the following questions:

1. Does greater frequency of student planning and generalizing engagement produce greater acquisition of integrated process skills? and

2. Are these effects consistent across levels of formal reasoning ability?

Procedures

This study involved twelve students in each of eight intact middle school science classes. Levels of student generalizing and planning engagement were manipulated by providing lesson plans to teachers together with model analysis and systematic feedback about performance. Student reasoning ability is measured by the Test of Logical Thinking (TOLT) developed by Tobin and Capie (1981). A posttest only control group design was employed involving three treatments that varied in levels of generalizing and planning engagement. Student engagement was coded using a time sampling procedure in which students were observed in random order. The Science Instruction Observation Guide (SIOG) used consists of the following four broad groups of behavior: (1) activity-focused behaviors, (2) teacher-focused behaviors, (3) self-focused behaviors and (4) off-task behaviors. Each of these four groups are then subdivided into specific categories. Multiple regression analyses were conducted on numerous models using Statistical Analysis System (SAS) procedures.

Results

Five of the twelve on-task categories in the SIOG were significantly correlated with process-skill achievement: planning, generalizing, comprehending, data quantification and data collection. Student reasoning ability correlates highly ($r = .67$) with process skill achievement and accounts for the largest portion of variation in student achievement. When just the specific engagement categories are tested as predictors of achievement, planning and generalizing emerge as the two best single predictors as well as the best two-variable model.

Conclusion

The results of this study suggest that the quality of engagement is indeed a factor in classroom learning. Levels of planning and generalizing engagement, in particular, promote acquisition of process skill objectives. The single best predictor of process skill achievement is reasoning ability. Student engagement is manipulable within the capacity of the student. Concrete students, however, do not seem capable of much generalizing or planning.

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Session J-4

STUDENT CONCEPTION OF STRUCTURE AND PROCESS IN CHEMISTRY (PART I)

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Very early in the study of chemistry the student is introduced to the concept of atom and atomic models. It is essential that students have a sound understanding of atomic models, if one is to build on them the study of more advanced topics. Thus the present study was undertaken to investigate the following questions:

(1) How do beginning chemistry students view the structure of a single molecule?

(2) How do these students conceptualize chemical processes such as synthesis and dissociation?

Methods

The sample consisted of 337 students from 11 tenth grade chemistry classes (average age 15) and represented a wide range of academic abilities. A written questionnaire was administered during one class hour (about 45 minutes), it consisted of five questions and involved extensive use of drawings.

Results

(1) How do students view the structure of a molecule?

The students were asked to describe by drawing the meaning of the symbols N_2O_4, $2NO_2$ and O_2. (An atom of N was represented by the letter N with a circle around it and similarly the atom O.) Most of the students in the sample (94%) realized that a molecule of an element, denoted by O_2, consists of two atoms bonded together. However, only 64% of the sample described correctly the molecule N_2O_4: About 2% drew a collection of free atoms without bonds. About 16% drew two distinct fragments - one corresponding to N_2 and the other to O_4. There were variations in the drawings and the fragments were either connected or not to each other ("mixture" or "glue"). About 11% drew an ordered row of six connected atoms with two atoms of N and then four atoms of O. Students drew consistently the same type of drawings also for $2NO_2$. Interviews with students confirmed that those in the fragment category indeed believed that the molecule is made up of two fragments. Also the meaning of the mixture, glue and row drawings was clarified.

(2) How do students conceptualize the chemical process?

The students were asked to describe, by drawing, the dissociation of Cl_2O into chlorine and oxygen. The question stated explicitly that the molecules of chlorine and oxygen were diatomic. About 39% of the sample described the products as Cl_2 and O rather than Cl_2 and O_2, i.e., these students viewed the process as a split into fragments. This view was also manifested in another question where many students claimed that one cannot get the product N_2O_5 from the reactants N_2 and O_2, since O_5 is not present among the reactants. Interviews with students confirmed this view.

Summary

This study indicates that a sizable proportion of beginning chemistry students have an additive rather than interactive view of structure and process; a compound is viewed as made up of fragments rather than as a new entity. Similarly, the chemical process is viewed as a process of mixing and gluing reactants, or as a split of a compound into fragments rather than as a process of bond breaking and bond formation.

Session J-4

STUDENT CONCEPTION OF GAS AND SOLID-DIFFICULTIES TO FUNCTION IN A MULTI-ATOMIC CONTEXT (PART II)

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The purpose of this study was to investigate how beginning chemistry students function in a multi-atomic context, e.g. describe the dissociation of a compound in the gaseous state into its elements. To function well in such a context the student must at least (a) realize that in a gas (or solid) there are many atoms or molecules, (b) know how the molecules are organized in a gas or solid, (c) know the structure of a single molecule. Difficulties with any of these aspects may cause errors; yet a student may know each aspect by itself, but have difficulty to coordinate all three together.

Method

This study was a part of a comprehensive investigation of student understanding of basic concepts in chemistry. Sample and method were discussed in the previous abstract (part I).

Results

The analysis considered how well students coordinate all three aspects mentioned above, as well as difficulties that students have with each aspect.

(1) Coordination of three aspects: About 70% of the sample answered correctly the simpler question where students had to describe the contents of a container filled with gas (an atom was represented by a letter with a circle around it). In a more complex question which involved a dissociation process. only 35% answered correctly.

(2) Multi-atomic aspect of matter: About 23%-30% of the students in our sample described consistently a gas or a solid by a single unit. These proportions went up to 88% when the student had to describe $O_{2(g)}$, probably because of translation difficulties.

(3) Organization of molecules in a gas or solid: All students who drew many molecules for the gas drew them in a scattered manner. However, among the 78% who drew many molecules for the solid, only about two thirds drew them in an ordered fashion.

(4) Structure of molecules: (a) Some students held the view that transition to a gaseous state involves a change in the molecule itself; about 8% of the sample described the gas O_2 by three atoms placed as far as possible from each other at the corners of the container. Similar notions were revealed in drawings of $O_{2(g)}$. (b) About 51% of the sample held the view that a molecule of gas or solid is a small portion of that substance carrying its macroscopic properties. Only 24% realized that when a material undergoes a change of state, the molecule does not change. Only 21% realized that the properties of matter depend in part on the fact that there is an aggregation of particles organized in some fashion. (c) About 55% of the students drew incorrectly the structure of a compound molecule (the same categories were found as in Part I).

Summary

Students have difficulty operating in a multi-atomic context. Some of the difficulties are special to this context, such as the view that in a gas the distance between the atoms in a molecule is larger than their distance in a molecule of solid. Many students fixated, in the multi-atomic context, on a single particle although they knew that a gas is composed of many particles.

Session J-5

CONCEPT MAPPING AS A RESEARCH TOOL

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What is Concept Mapping

Concept maps are two-dimensional representations of relationships between concepts expressed simply as hierarchical arrangements of concept labels and linking words. We define concepts as regularities in events or objects designated by a sign or symbol (the concept label). Two or more concepts linked together meaningfully form propositions that represent a specific relationship between the two concepts, such as "dogs have tails." In turn the meanings of a concept is "dogs wag their tails"; "dogs are mammals"; etc. are propositions that give meaning to the concept dog when the propositions are learned. Concept maps represent simple propositional structures that illustrate principal meanings of the component concepts.

Since 1975, we have employed concept mapping in most of our research studies, either as a tool to analyze and represent the conceptual and propositional structure of a body of subject matter or to represent a segment of cognitive organization for a given student. In some of our work, concept maps have been constructed from propositions stated by students during a clinical interview, whereas other studies have used concept maps constructed by students (after some instruction on concept mapping.) Various scoring keys have been devised to qualify assessment of concept maps, thus permitting statistical analysis. Concept maps are one useful form of data reduction when clinical interviews are used with students. Students from age six and older have been successfully instructed in concept mapping.

Workshop Plan

1. Several illustrative concept maps will be presented along with a brief introduction to the psychological principles underlying concept maps as we have developed them.

2. A simple concept map will be constructed on an overhead transparency by the workshop leader from a short text, and also from a list of related concept words.

3. Participants will construct a simple concept map from a short text, and sample maps will be placed on overhead transparencies and discussed. Workshop leader and helpers assist participants in construction of maps.

4. Scoring keys will be discussed with sample maps projected from transparencies and scored with group discussion.

5. Participants will be given sample concept maps to score; their sample maps will be projected with group discussion of scoring by individual participants.

6. Examples of procedures to teach "concept mapping" to students will be provided, along with discussion of the procedures.

7. A list of research questions dealing with the structure and use of concept maps will be presented and discussed.

CREATION, EVOLUTION AND CURRICULUM

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This paper is a philosophical analysis of the creation/evolution conflict as it relates to the structure and function of the curriculum. Philosophical analyses of the concept of teaching are taken as the starting point for examining wider curricular implications of the conflict. The paper attempts to show that current literature on the topic tends to be based on issues within philosophy of science and that this focus is inadequate as the only grounds for positing and weighing curricular alternatives. Distinctions from conceptual analyses of teaching (e.g., indoctrination/instruction) are used to address the question how evolution and/or creation could be taught in a defensible manner.

Session K-1

THE CLOUD OF CREATIONISM: IS THERE A SILVER LINING?

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The revival of interest in creationism does not make many biology teachers happy. The most common reaction is one of rejecting creationism as having any potential for positive influence on biology education.

A more optimistic view will be set out in this paper. It will be argued that:

1. the current evolution/creationism controversy could prompt a serious and rational debate on the composition of introductory high school biology courses; and

2. biology teachers; knowledge of science in general, of evolutionary biology and of the history and philosophy of science could be enhanced because of the creationist/evolution controversy.

The debate would focus on the present practice of giving approximately equal weight to all areas of biology in introductory courses. Since evolutionary biology is the "atomic theory" of biologists, it should receive increased coverage. The benefits to students of this increased coverage are that it would increase their:

1. awareness of the importance of controversy in science;

2. understanding of the intellectual development of a discipline;

3. knowledge of the current controversies in evolutionary biology and paleobiology; and

4. understanding of the "nature of science."

Session K-1

EVOLUTION AND CREATIONISM: A QUESTION OF DEMARCATION

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In the current controversy concerning the inclusion of "scientific creationism" in the science curricula the courts and legislatures will undoubtedly play a major role. Regardless of the legal outcome, the assertions made by creationists reflect a significant philosophical question, the demarcation question, to which science educators must respond. Implicitly, the science curriculum is in part a result of applying demarcation criteria (astronomy, not astrology, is taught as science). The creationist claim is that no substantive criteria can be invoked which would result in the conclusion that evolutionary theory is science and creationism is not. In support of that claim the writings of K. Popper and T. Kuhn are brought forth.

Discussions concerning the demarcation between science and non-science (or pseudo-science) are by no means exhausted by a reading of Kuhn and Popper. However, a critical examination of their ideas, in conjunction with a philosopher who claimed to have significantly improved Popper's demarcation criteria, I. Lakatos, provides a valuable introduction for science educators concerned with the question of demarcation raised by creationists. From such an analysis, demarcation criteria will emerge to support the scientific status of evolution and the rejection of creationism as science.

Session K-1

EVOLUTION AS AN HEURISTIC: A DARWINIAN DEFENSE

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In spite of the almost unanimous rejection by the scientific community of the creationists' claim for scientific validity, those laymen whose responsibility it is to decide on school curricula (legislators, school boards, and school administrators) continue to be persuaded that "scientific creationism" deserves equal time in the public school science curricula. The creationists have been largely successful in keeping the debates focused on technical arguments so that the decision makers, not typically drawn from the ranks of scientists, can often be persuaded that the choice is a matter of personal opinion and equal time is the fair procedure to follow. I offer in this paper a criterion less dependent on technical evidence or argument and by which the superiority of evolution as a scientific theory is unambiguous. Evolution is and has been a superb scientific heuristic, that is as a theory it organizes the knowledge of a vast array of particular disciplines into an orderly and coherent structure. At the same time it continues to suggest questions to be answered by a further exploration of nature and thereby leads to the continued increase in natural knowledge. Creationism utterly fails by these standards. I support my position by a brief analysis of the historical introduction of Darwin's theory of evolution and his defense of it.

It has been implied that if creationism and evolution were equally available in the classroom, creationism would come out the winner. History suggests otherwise, for nearly every natural historian before the appearance of the Origin of Species in 1859 was a creationist, but ten years later virtually all of them had become evolutionists. The reason seems to have been that the theory explained so much, it gave coherence to an enormous body of general information. In response to early criticism Darwin wrote that "I do not pretend to adduce direct evidence of one species changing into another, but that I believe that this view in the main is correct, because so many phenomena can be thus grouped together and explained." Specifically Darwin suggested that it explains " a large number of facts in geographical distribution--geological succession, classification, morphology, embryology, etc." A woodpecker living on the treeless plains of La Plata makes no sense from a creationist perspective, but is readily understood from an evolutionary one. Similarly evolution gives a plausible and rational explanation why the cave-dwelling creatures in North America so closely resemble the creatures outside the caves there, and so little resemble the creatures dwelling in the caves of Europe, while a creationist perspective has nothing to say on this. Creationism answers all such question with the same answer: things are the way they were created. Such a view not only fails to organize present knowledge in any useful way, it also fails to generate questions whose attempted answers generate new knowledge.

Session K-2

COGNITIVE DEVELOPMENT AND ACADEMIC ACHIEVEMENT IN HEARING IMPAIRED EARLY ADOLESCENTS

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The hearing impaired early adolescents do not verbally receive feedback about the environment or manipulate symbols as do their hearing counterparts. Thus, the thought patterns and processes developed in cognitive structures for these students do not use auditory input or vocalization as a central means of processing the environment. The major difference between hearing and hearing impaired early adolescents may be in the form, rate, or both form and rate that the cognitive symbol system assumes and develops.

Researchers investigating cognitive development of hearing impaired students in small sample studies have reported minimal discrepancy and similarities in the development of thought processes (Furth, 1964, Furth and Youniss, 1971). Yet, in national samples surveying hearing impaired students, many are functioning in classroom materials two to five years lower than their hearing peers. Research to date also indicates that science is generally not taught, or is taught using traditional school science materials, in a large majority of hearing impaired early adolescent classrooms. This leaves the teacher with the full responsibility (if science is taught) of adapting text, activities, sequence and evaluation among other deficiencies to the special needs of the student (Sunal and Burch, 1978).

The purpose of this study was to determine the level of cognitive functioning of early adolescents taken from a national sample of hearing impaired classrooms and relate this level to performance and achievement in classroom work. The relationship of appropriateness of classroom instruction was also investigated.

One hundred and six early adolescent subjects (65 DB or greater hearing loss) enrolled in 18 classrooms from hearing impaired schools in three states were given a series of developmental tasks (10) at the beginning of the school year and again eight months later. Classroom variables involving variety and forms of feedback and activity were monitored. Ss (mean age 11.5 years) were also administered achievement tests, the dependent variable.

Large differences (up to six years in comparable attainment) were noted between the cognitive developmental level of hearing impaired students and their hearing peers, showing a discrepancy with earlier research results. This discrepancy accounted for a large proportion (10-15% for various ages) of the differences noted in the student's performance on achievement tests in science. After long sustained periods of science instruction rated as much higher in variety and level of feedback and activity than previous student experience, large discrepancies noted in cognitive developmental level at the beginning of the school year diminished. Discrepancies in classroom functioning with instructional materials were decreased to an average of one year or less. Students who remained in classrooms of high or low variety and level of feedback and activity showed small changes in cognitive developmental level.

This research supports the hypothesis that the various thought processes typical of concrete operations and formal reasoning are functional and similar in form and development rate between hearing impaired and hearing adolescents. Discrepancies noted in classrooms were found to be related to problems in appropriateness of instruction. This research suggests an effective process for measuring hearing impaired cognitive developmental level for possible grouping and monitoring of student outcomes. It also supports the idea that a planned curriculum, effective with hearing adolescents and adapted to the special needs of the hearing impaired, would be successful in developing thinking and science achievement.

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Session K-2

FORMAL OPERATIONAL THINKING OF GIFTED STUDENTS IN GRADES 5, 6,7 AND 8

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The Test of Logical Thinking was developed as a group paper and pencil test of formal thinking based on Piagetian protocols. Capie and Tobin (1980) reported reliability and validity values that supported the test for further use in investigation of formal thought and variables which might contribute to the attainment of formal thought. This study reports the scores of 220 students in grades 5, 6, 7 and 8 enrolled in a summer program for the gifted on TOLT Form A. Questions asked with regard to this population included:

1. How does the performance of a gifted population compare to the normed group?
2. What variables (age, grade, IQ, achievement) relate to score on the TOLT?
3. What error patterns exist in the answers of gifted students on the TOLT?
4. Is there a sequence of questions or subscales which demonstrates developmental change in formal thought?

Form B of the TOLT was administered to sixty students in addition. Forty of these tests were given after two weeks as an alternative form reliability check.

The measurement scores for Form A reported previously were upheld with the gifted population. A unitary factor solution accounted for almost 40 percent of the variance. Coefficient alpha for the test was near .80. Overall performance of the gifted students was much higher than the scores for the groups reported previously. While almost fifty percent of the previous group had scored zero on the ten item scale, only 10 percent of the gifted group scored 0 correct. The gifted group also demonstrated a high percentage who scored at the criterion of 4 established for formal thinking while almost none of the comparable age group scored 4 or higher.

Preliminary analysis of variables which relate to performance on the TOLT revealed that age in months is the first predictor and Science Achievement is the second predictor. Further analysis is being conducted to remove the influence of intercorrelations among the student variables. Error analysis by age and grade level demonstrated changes in type of answer and reasoning used.

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Session K-2

DIAGNOSIS OF LEARNING AND REASONING DIFFICULTIES OF 9TH GRADE PHYSICS STUDENTS AS A BASIS FOR DEVELOPING REMEDIAL TEACHING METHODS

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The research reported here was designed to identify the previous knowledge, rational and linguistic prerequisites of an existing 9th grade physics course and to test in natural classroom conditions the effectiveness of providing immediate feedback, based on the cognitive conflict strategy, as a method of remedial teaching. The research was conducted in four consecutive stages. In the first stage, a detailed task analysis of the contents of the course was performed. Following this analysis, a detailed list of the prerequisites of the course was compiled. This list was utilized for the preparation of four paper-and-pencil, multiple choice, background tests: "Algebra," "Graphs," "Reading Comprehension" and "Separation of Variables." In addition, a clinical physics questionnaire was prepared. The investigative style of this questionnaire was an adaptation of the clinical interview originated by Piaget: students were individually interviewed, their responses were described in detailed protocols and analyzed. Information about deficiencies in students' prerequisite knowledge and skills, as well as an understanding of the reasoning difficulties they face during their work in the laboratory, was obtained at this stage of the study. In the following stage, this information was used in the development of a remedial teaching method and in the preparation of its accompanying learning materials. Two premises served as guidelines in the development of these methods and materials: (a) content related feedback should be provided to each student, individually, immediately after he finishes the study of a specific topic. This feedback was designed according to the guidelines of the cognitive-dissonance approach. (b) The feedback materials should be presented in a way that closely simulates the situations and equipment the student met in the laboratory exercises. Drawings and pictures, as similar as possible to the experimental set-up, were included in the feedback materials prepared for the students. A set of 20 diagnostic self-test booklets were prepared, along with their corresponding answer booklets for immediate feedback.

In the fourth and final stage of the study, the impact of the new teaching methods and materials on students' achievement was tested. An experimental group of 44 classes and a control group of 14 comparable classes took part in the experiment. A total of 1500 students were involved, during a period of 7 months. The experimental group used the new method and materials in addition to the regular physics textbook. The control group used only the regular textbook and the traditional teaching methods. Three multiple-choice achievement tests were prepared and administered during this stage of the study.

Analysis of the results of these tests for the total population shows that achievement in physics was strongly dependent on background parameters, and deficiencies in prerequisites could explain over 40% of the variance in achievement scores.

However, the comparison of the achievement in the experimental group with that of the control group, after controlling for differences in the four background tests, indicated that achievement was significantly improved by the use of the methods and materials developed during the study.

This strategy, of clearly identifying the deficiencies in prerequisites, and the consequent application of remedial feedback materials designed to compensate for such deficiencies, was found to be a very effective approach in our case. We believe that similar strategies will prove useful in other areas of science teaching.

Session K-4

A STUDY OF THE RELATIONSHIP BETWEEN QUALITY OF IMPLEMENTATION AND TYPE OF SCIENCE TEACHING STRATEGY AND STUDENT ENGAGEMENT

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Because effective teaching enhances student learning, it is a crucial goal of the teacher training program. It is important to find out what type and quality of teaching strategies stimulate the students to become engaged in the business of learning.

Purpose

The objective of this study was to identify the relationship between the type and quality of science teaching strategy and student engagement.

Procedures

Six student teachers and their students in middle and high schools in Athens and Jefferson, Georgia, were observed on ten occasions during Fall Quarter, 1981. A total of 60 observations were made of all student teachers and ten of each of their students. During each observation period, the type and quality of implementation of teaching strategy were identified and student engagement was rated.

The Teaching Strategies Observation Differential (TSOD) (Anderson, James, and Struthers, 1974) was used to measure teaching strategies. It was selected because of its ability to generate a score on a direct-indirect teaching stratgey continuum.

Ten students were selected for each classroom observation. Each student was observed to code his/her on-task or off-task behavior at one minute intervals (Anderson, 1976) throughout the lesson.

The quality of teaching was measured using a rating system developed by the investigator. Criteria for each teaching strategy were defined which assessed the quality of implementation of that strategy. High quality was indicated as a greater number of criteria were met.

Results

Data collected were examined by regression analyses. The results indicated that the type and quality of implementation of teaching strategies did significantly and positively relate to student engagement. Analyzed individually, the type of teaching strategy predicted 12 per cent of the variance in engagement, while the quality of teaching strategy predicted 35 per cent. Overall, both factor models, the type and quality of teaching strategy, predicted 37 per cent of the variance in engagment, the data also showed that the more indirect the teaching strategy, the greater the students' involvement in learning tasks.

Conclusions

The type as well as the quality of implementation of teaching strategy has an influence on student engagement. Also, the more indirect the teaching strategy, the higher the student's engagement in learning. Both of these factors should be emphasized and considered as part of the teacher training program.

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Session K-4

FACTORS INFLUENCING THE RECEPTIVITY OF EDUCATORS TO CURRICULUM CHANGE

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Many studies have been reported in the literature on the topic of implementation of curriculum innovation and change, however most of this work is based on major curriculum changes, e.g. BSCS, PSSC, Project Read (Helgeson et al, 1978; Weiss, 1978). The attitudes of teachers have been examined in relation to these changes (Bird, 1971; Hall, 1976; Howe, 1978; and Welch, 1979).

The study proposed here deals with the use of curricular materials on a current environmental topic - acid precipitation, more commonly known as 'acid rain' - by secondary science teachers in the state of Minnesota. These materials were designed to be utilized during a 2-3 day time period. Therefore, inclusion of this topic does not represent a major curricular change on the part of the teacher. For example: acid precipitation may affect the germination of seeds. Most life science classes study seed germination. Will teachers incorporate an activity addressing this topic?

The Rochester Environmental Education Board, the Freshwater Biological Research Foundation, the Minnesota Environmental Education Board, and Minnesota Sea Grant - Duluth, 1979-80, and a major grant from ESEA Title IV-C Acid Precipitation Awareness in 1980-82 have provided the author and others with the opportunity to develop curriculum and to give teacher workshops on the topic of acid rain. Multi-disciplinary activities easily incorporated into on-going curriculum of life, earth, physical science in the junior high and biology and chemistry in the senior high school as well as social studies at both levels were developed. The activities are activity-centered, inquiry oriented, and designed to create scientific awareness, as well as enhancing decision-making abilities.

During this two year development phase, many different types of presentations, seminars and workshops have been given to hundreds of teachers throughout the state. Some workshops were to discuss the general topic of acid precipitation and others were specifically designed for science teachers.

Many teachers have been interested in implementing the new curriculum; others are not. To determine what factors influence the receptivity of educators to curriculum change, and why some teachers will implement acid precipitation activities in the classroom, this study is proposed.

This study examines by survey and case study techniques the following two major questions:

1. Are educators who have a tendency to accept new knowledge more likely to include a current environmental issue into ongoing curriculum in science grades 7-12? The Welch Curriculum Attitude Survey, based on the seven Havelock dissemination and utilization factors, will be administered to science teachers in Minnesota who have and have not used the 'acid rain' materials. Each of these two larger groups will be divided into three smaller groups identified as those with a high tendency to accept new knowledge, those who score in the mid-range, and those with a low tendency to accept new knowledge.

2. What are the characteristics of educators that influence their receptivity to curriculum change? By means of a general questionnaire sent out along with the survey and case studies of individuals within each grouping, additional factors influencing educators' receptivity to change will be identified. Satisfaction and enjoyment of the job, the pupil-teacher relationship and knowledge of science process skills

are a few of the questions which will be addressed by case study.

Outcomes

The identification of the most appropriate target audience for the introduction of another environmental problem will be considered.

Another outcome will be a better understanding of the factors affecting knowledge dissemination in schools and an indication of strategies, directions and dissemination techniques which future environmental curriculum projects could utilize.

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